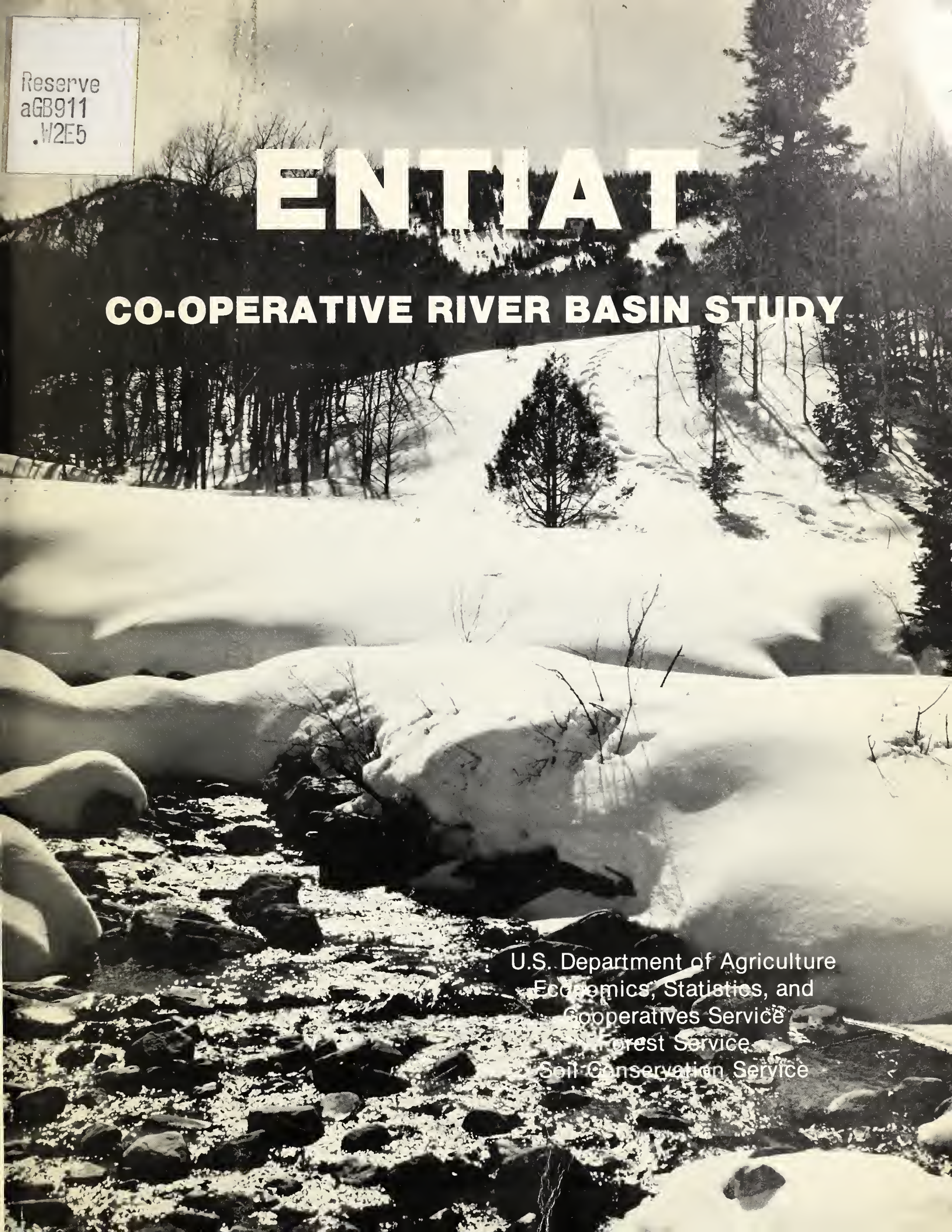


ENTIAT

CO-OPERATIVE RIVER BASIN STUDY

U.S. Department of Agriculture
Economics, Statistics, and
Cooperatives Service
Forest Service
Soil Conservation Service

ENTIAT

Cooperative River Basin Study

April 1979

Table of Contents

Table of Contents

Table of Contents

TABLES

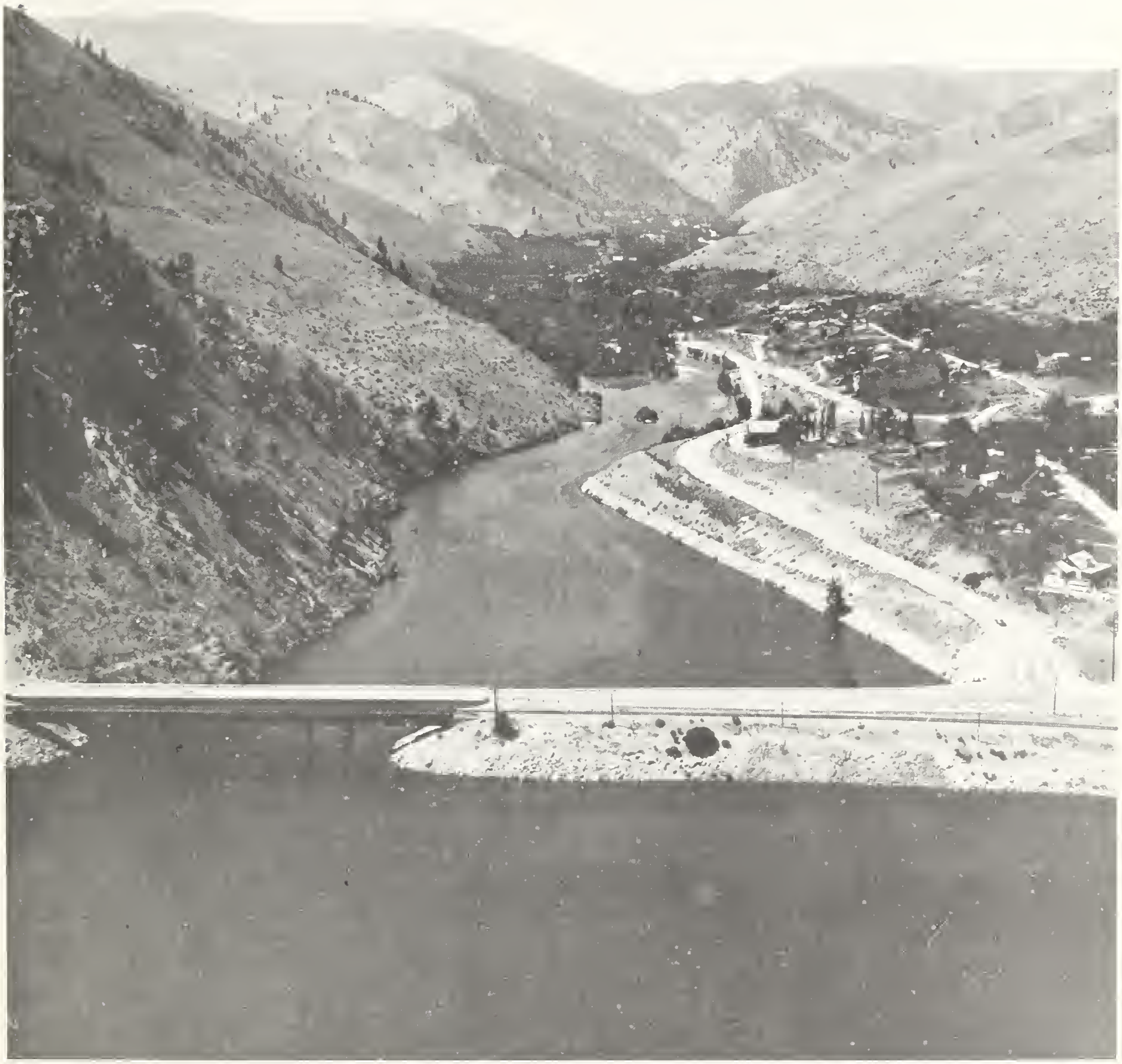
Table of Contents

FIGURES

MAPS

PREFACE

The Entiat River Basin is located along the eastern slopes of the Cascade Mountains in north-central Washington. The Basin drains directly into the Columbia River, about 20 miles north of the City of Wenatchee in Chelan County. The drainage area is about 266,500 acres. Topography is extremely steep and dissected. Vegetative cover is primarily forest. Eighty-seven percent of the Basin is in



The Entiat River at its confluence with back water from Rocky Reach Dam on the Columbia River. Prior to sedimentation, a boat basin was planned.

public ownership, primarily National Forest. In the lower valley are 1,300 acres of orchardland, much of it classified as prime agricultural land.

During a 2-week period, August 23 through September 7, 1970, forest fires burned 118,000 acres in central Washington. Three of these — the Entiat, Gold Ridge, and Shady Pass fires — destroyed 58,000 acres of vegetation within the Entiat River Watershed, 22 percent of the Watershed cover. Although rehabilitation was begun immediately to reestablish vegetation over much of the burn, high intensity rainstorms in June 1972, and again in January 1974, caused major erosion and flooding through the Watershed. Houses, bridges, roads, water systems, irrigation diversions, and fish habitat were destroyed. Large areas of streambank vegetation and valuable orchard and pasture were lost to bank erosion. Four lives were lost in a massive slide that partially destroyed a residential tract in the upper valley.

Public concern about the repair of past damage and prevention of further degradation continues. At a meeting in the spring of 1975, local citizens met with agency and government representatives to explore action needed to correct or reduce erosion, sedimentation, and associated problems. A citizens' steering committee was established to continue the pursuit of a viable remedial program. At subsequent meetings, the Entiat Citizens' Committee developed a problem chart (Appendix B). Problems which resulted from changes in the Watershed due to the 1970 burn and which are

Looking towards the Entiat River from Crum Canyon.

found on the lower Entiat River are categorized as "downstream problems." These constitute the Committee's concern and include river bank erosion, sediment deposits, sediment in irrigation systems, degradation of fish habitat and drinking water, hazard to lives and structures, and economic and aesthetic losses. Those problems in the upper Watershed were called "upstream problems" and dealt mostly with watershed conditions.

Various Federal agencies have programs which addressed the stated concerns. A coordinated approach was desired.

The USDA Eastern Washington Cooperative River Basin Study was authorized in 1975. The Forest Service; Economics, Statistics, and Cooperatives Service; and Soil Conservation Service were developing the plan of study when the Entiat need became apparent. At the request of the Entiat Citizens' Committee, the Entiat River Basin was included as a first priority for study.

A USDA Cooperative River Basin Study is designed to collect and analyze data pertinent to water and related lands problems. From this analysis a program of action may be prescribed. Although the focus of these studies is identification of appropriate USDA projects and programs, those of other Federal departments are also considered and recommended. Cooperative River Basin Studies may vary with regard to objectives, scope, and expected results. The Field Advisory Committee which is responsible for establishing these and directing the Study consists of Forest Service; Economics, Statistics, and Cooperatives Service; and Soil Conservation Service representatives. A representative of the Washington State Department of Ecology has been added for the Eastern Washington Study. Specific responsibilities of agencies conducting the Eastern Washington Study are spelled out in the plan of study.

The overall objective of USDA participation in this Study is to develop an integrated protection plan for the Entiat Basin. It includes development of a program of structural and land treatment measures that primarily address the problems identified by the Entiat Citizens' Committee. It was determined early in the Study that the concerns of the Citizens' Committee were attributable to increases (since the 1970 fires) in water runoff, subsequent erosion, and sedimentation. Major study elements, then, were to determine the location, type, and rate of erosion and sedimentation, evaluate their onsite and offsite effects, and develop alternative means of reducing erosion and minimizing adverse effects of sediments. A priority is assigned to proposed remedial and preventative activities which may occur on a variety of fronts. The cost of this activity is related to a predictable, expected reduction in one of the problem areas. The value of this reduction is stated in terms of its effect on stated citizen concerns.

SUMMARY

The Entiat Study has shown that:

Problems identified by the Citizens' Committee (Table 1) are the result of high volumes of runoff water, erosion, and sedimentation (Figure 1). High runoff occurs as a result of snowmelt with heavy precipitation and periodic intense thunderstorms. Destruction of 22 percent of the Basin's vegetation by fire in 1970 has increased the severity of runoff, erosion, and sedimentation. Nine alternatives have been developed to address runoff erosion and sedimentation problems (Table 2, Page 12).

Sheet and rill erosion are not serious problems on most agricultural land. A major problem during high runoff is the streambank erosion loss of agricultural land including prime orchard.

Approximately 300 acres of nonirrigated cropland is subject to moderate sheet and rill erosion.

Average rangeland erosion rates are 0.75 tons per acre per year.

Approximately 2,900 feet of riverbank fronting orchards are subject to severe erosion. An additional 9,250 feet is less severe.

The 50- and 100-year frequency flood inundates 84 acres of orchard and 327 acres of pasture and hayland. No feasible measure was found to protect against this inundation.

The 10-year interval flood is mostly contained within the Entiat channel, but results in erosion of the upper bank. Channel cleaning and bank stabilization will alleviate this.

Average annual loss of agricultural land through streambank erosion has been 1.5 acres. Normal annual erosion accounts for 0.5 acres per year, and storm events cause an additional 1.0 acre loss per year.

Mean annual surface erosion rates on forest lands

Table 1.—Concerns as Expressed by the Citizen's Committee[1]

Location	Concern
Upstream Problems	Channel Stabilization
(Above Ardenvoir)	Large revegetation program
	Reforestation
Note: These "problems" are statements	Establish vegetation on cutbanks
of condition or needs in the uplands	Channel scouring & slumping
	Control of stream channel meander
	Identify danger areas on fans
	Mass land movement
	Channel clearing and snagging
Downstream Problems	River bank erosion
(Below Ardenvoir)	Depositions at Entiat Mouth
Note: These "problems can be	Sediment in irrigation systems
considered to be effects of runoff,	Degradation of fish and wildlife habitat
erosion and sedimentation	Drinking water quality
	Public safety
	Damage to structures
	Economic and aesthetics

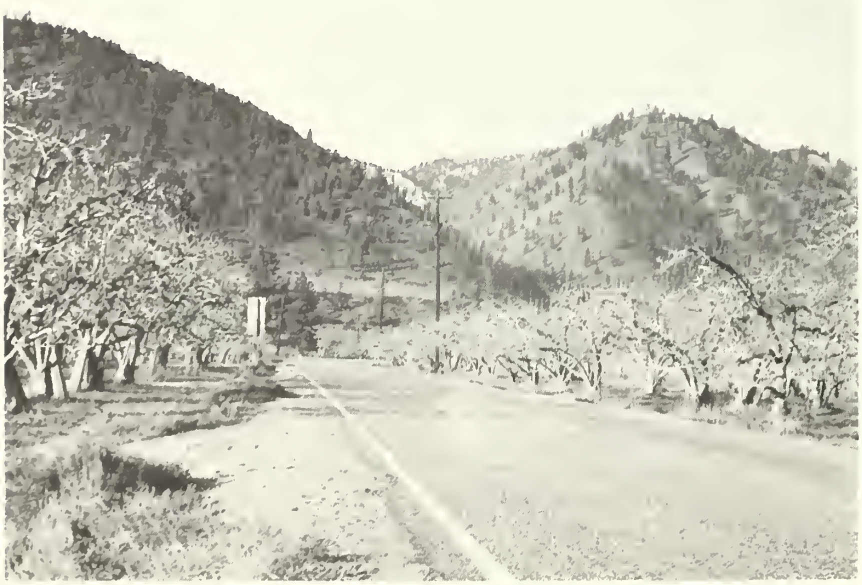
[1]Also, see Appendix B

range from .001 to 4.17 tons per acre per year on specific land types. There is a direct correlation between surface erosion rates and the land type use.

The total mean annual surface erosion from forested lands amounts to 48,336 tons per year, or an average of 120.20 tons per square mile per year.

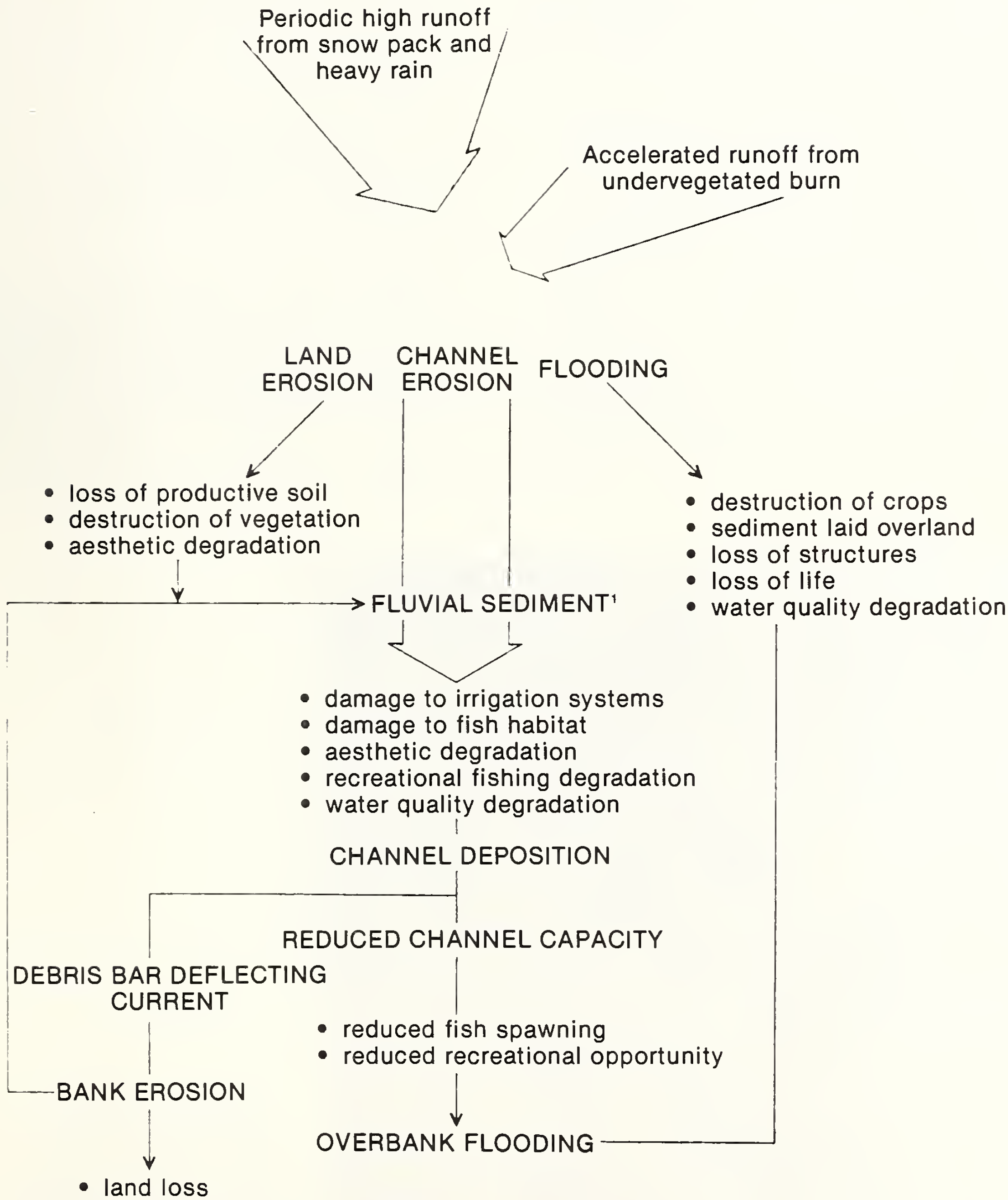
The 297 miles of stream channel contribute a mean annual erosion total of 22,200 tons per year or an average of 74.75 tons per mile per year.

View into the Lower Entiat River Valley. Note sparse forested slopes due to limited precipitation and available soil moisture.



Fruit Orchards along the Lower Entiat Valley are a primary source of the area's stable economy.

Figure 1.—Problems Cause & Effect



[1]Fluvial sediment is defined as being sediment produced by or contained in a river or stream.

Mean annual erosion from all forest land sources (land surface and stream channel) amounts to 70,536 tons per year, an average of 175.7 tons per square mile per year.

In the forested lands mean annual fluvial sediment rates range from .001 to .265 tons per acre per year. Total fluvial sediment from the land system amounts to 7,504 tons per year or 18.7 tons per square mile per year. The channel system contributes 18,867 tons per year of fluvial sediment or an average of 63.53 tons per mile of perennial stream.

The mean annual fluvial sediment from all sources (land surface and stream channel) amounts to 26,371 tons per year, an average of 65.69 tons per square mile per year.

Mean annual sediment has increased from 9,311 tons per year to 25,744 tons per year on forested lands, — a 276 percent increase — due to wildfire, flooding, and salvage logging conditions since July 1970.

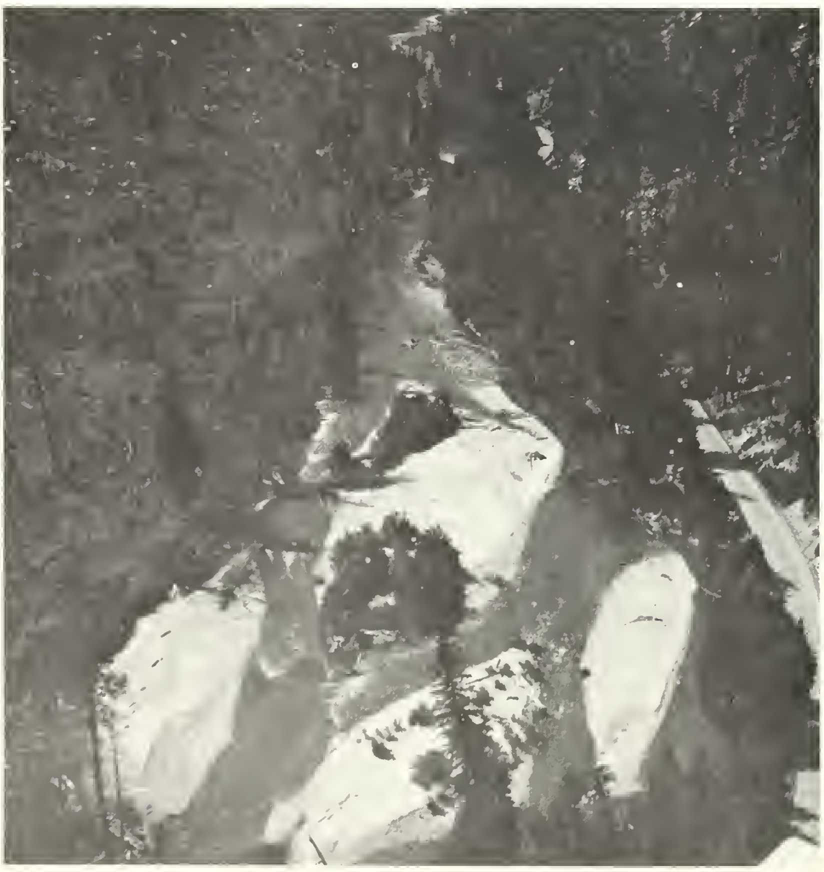
Sediment deposition in streams is a major factor in reducing channel capacity and deflecting current into banks.

Seventy-two percent of sediment in streams originates from the stream channels. If water quality objectives in the Basin are to be accomplished, efforts need to be concentrated on streambank and lower slope erosion sources.

Stream channels were placed in seven categories of stability ranging from excellent to very poor (Stream Channel Stability Map). This categorization serves to establish priorities for stabilization work.

Seventy-one miles of channel were in fair to very poor condition from a stability standpoint. This 24 percent of the Basin's streams produces 68 percent of the gross sediment tons per year. The mean sediment delivery ratio is 0.85 from these channels and lower slopes.

Similarly, land areas have been stratified to in-



Aerial view of Upper Entiat River typical of stream reaches within the 1970 Burn. Note debris deposition and channel braiding. Much of this sediment moves further downstream during each annual flood peak.

dicate different levels of land erosion and sediment yields. (Land Erosion and Sediment Yield Map).

Twenty percent of the mean gross sediment from land sources occurs from less than 4 percent of the land.

Study data indicate a 44 percent mean annual increase in total water yield from the entire Watershed following the 1970 fires. Revegetation will reduce this as tree and ground cover develop.

Revegetation of burn areas has been effective in reducing sheet erosion, but opportunities for further reduction exist. (See Critical Erosion and Rehabilitation Needs Map.)

Even though 80 percent of forest lands planned for reforestation have been reforested, the trees are young and crown cover is not yet a factor in precipitation interception. Reforestation will be completed by 1984.

A portion of the Basin's problems are attributable to natural geologic processes. For instance, many alluvial fans from tributaries are subject to periodic flood, and stream channels, through fans, tend to shift.

The Basin has had large fires, but the fire history is not severe and only the fire in the Mad River Drainage in the 1880's approaches the devastation of the 1970 wildfire.

Local climatic conditions create frequent thunderstorms with intense precipitation. While this Study was in progress, a disastrous combination of fire and storm occurred. In July 1976, the 9,000 acre Crum Canyon wildfire burned 3,000 acres in the northeast corner of the Basin. On June 13, 1977, a localized storm dropped 4 to 6 inches of hail on the burn area in less than an hour. A second high intensity storm of the same magnitude over the same area occurred 42 days later. Both caused severe damage to the Watershed and downstream improvements.

Unstable river bank and bottom contributes about 200 tons of fluvial sediment per mile per year at this reach.

Table 2(a).—Comparison of Alternatives
Fluvial Sediment Reduction

	Alt 1[1] Without Plan	Alt 2	Alt 3	Alt 4	Alt 5
Reduce sediment from Stream Channel Sources to:	(Pre-Burn Condition) 32 Tns/ mile per year	191 Tns/ mile per year	150 Tns/ mile per year	85 Tns/ mile per year	(Pre-Burn Cond.) 32 Tns/ mile per year
Reduce sediment from Stream Channel Sources to:	32 Tns/ mile per year	191 Tns/ mile per year	150 Tns/ mile per year	85 Tns/ mile per year	82 Tns/ mile per year
Tons sed. reduction	15,682	2,805	7,580	12,795	15,682
% reduction from post-burn Sed. load increase	96%	17%	46%	78%	96%
Time needed	50 yrs	7-10 yrs	7-10 yrs	7-10 yrs	7-10 yrs
Type of Treatment	Ongoing program at existing level. Heavy reliance on Natural healing process.	Stabilize severely eroded reaches by reveg. and rock riprap	Same as Alt 2	Same as Alt 2	Same as Alt 2
Channel treated — Miles	As programmed	11	36	71	105
Cost/Ton Sed. reduction	——	$161.	$129.	$ 108.	$ 99.
Total Cost[2] (Thousands)	$1,000.	$453.	$975.	$1,380.	$1,566.
Remarks	409,275 Tns of sediment will enter stream during 50-year recovery period				

[1]Time, continued degredation from sediment and significant expenditure are principal disadvantages of Alt. 1.

[2]Dollar amounts in terms of 1978 dollars.

Table 2(b).—Comparison of Alternatives (cont.)
Erosion Reduction (Land Sources)

	Alt 1 Without Plan	Alt 2	Alt 3	Alt 4
Reduce Mean Ann. Soil Erosion to:	(Pre-Burn Cond.) 0.05 tons per acre/year on all lands	0.5 tons per acre/year on all lands	0.19 tons per acre/year on all lands	0.1 tons per acre/year on all lands
Tons Eros. Reduction (Mean Annual)	40,200	2,650	12,711	20,945
% Erosion Reduction	74%	5%	23%	39%
Time Needed[1]	40 yrs.	5 yrs.	10 yrs.	12 yrs.
Type of treatment	Ongoing program at existing level. Heavy reliance on Natural healing process	Stabilize worst sources by vegetation. Include roads & gullies, grass, trees, fertilizer	Same as Alt 2	Same as Alt 2
Acres Treated	As programmed	16,734	83,188	104,249
Cost/Ton of Erosion Reduced		$ 257.	$ 128.	$ 138.
Total Cost (Thousands)	$800.	$ 681.	$1,625.	$2,880.
Remarks	420,000 Tns of soil will be lost offsite during 40 yr. recovery period			
Resultant reduction in fluvial Sediment (Tons)	——	$ 612.	$3,026.	$3,730.
Cost/Ton of Sediment Reduced		$1,113.	$ 537.	$ 772.

[1]For Alt's 2, 3, & 4 — Time needed following treatment to achieve expected Erosion Reduction.

Table 2(c).—Comparison of Alternatives (cont.)
Summary of Conservation Practices Specifically Intended to Address Problems on Agricultural Lands

Conservation Practice	Unit	Amount	Cost/Installation Unit	Cost/Installation Total
Stubble Mulch Tillage[1]	Ac.	300	$ 25	$ 7,500
Stream Channel Stabilization	Ft.	2,950	$ 30	$ 88,500
Clearing	Cy.		Not Estimated	
Protection of Irrigation Systems — Sediment Damages				
Alt. #1 Sediment Ponds	Ac.	1,300	$ 40	$52,000
Alt. #2 Rainey Collectors	Ac.	1,300	$ 30	$ 39,000
Alt. #3 Wells	Ac.	1,300	$ 80	$116,000
Alt. #4 Sand Filters	Ac.	1,300	$ 40	$ 52,000
Alt. #5 No Action	Ac.	1,300	$244	$317,000[2]

[1]In place (see discussion page 114). Not treated separately as an alternative.

[2]Indicates estimated Average Annual cost of repair and clean-out of sprinkler systems, pumps and irrigation ditches.

Table 2d.—Comparison of Alternatives and Their Effects on Citizen Identified Problems.

	Fluvial Sediment Reduction Alt. 1	Fluvial Sediment Reduction Alt. 2	Fluvial Sediment Reduction Alt. 3	Fluvial Sediment Reduction Alt. 4	Fluvial Sediment Reduction Alt. 5	Erosion Reduction — Land Alt. 1	Erosion Reduction — Land Alt. 2	Erosion Reduction — Land Alt. 3	Erosion Reduction — Land Alt. 4	Flood Damage Reduction 1	Flood Damage Reduction 2	Flood Damage Reduction 3	Single Purpose 1	Single Purpose 2	Single Purpose 3
Action Sediment— Expected Reduction	OnGoing PreFire cond (50 yr. time)	Veg. RipRap 2,805 Tns.	RipRap Veg. 7,580 Tns.	RipRap Veg. 12,795 Tns.	RipRap Veg. 15,682 Tns.	OnGoing PreFire cond (40 yr. time)	Veg. 612 Tns.	Veg. 3,026 Tns.	Veg. 3,730 Tns.	Riv. Bank Protection Not calc	Const. Dikes	Channel Clearing	Protect Irriga. See Tab.2b	Entiat Mouth See Ch.4	Fish Spawn See Ch.4
Erosion - Expected Reduction							2,650 Tns.	12,711 Tns.	20,945 Tns.	2,950 lin.ft.					
Flood - Expected Reduction Remarks										88,500	50 yr & 100 yr Not feas.	Not estimated		See Discussion Problem Effects Section	
COST	$1,000,000	$453,000	$975,000	$1,380,000	$1,566,000	$800,000	$681,250	$1,625,000	$2,880,000	$88,500	$560,000	Not estimated			
PROBLEM ADDRESSED[1]															
EROSION OF LAND		1	2	3	3		2	4	4	4					
FLOOD OF LAND			1	1	3						4	4			
DEPOSIT OF SEDIMENT		2	3	4	4		1	2	2	2				1	
SED. IN IRRIGATION		2	3	4	4		1	2	2	2			4		
FISHERY DEGRADATION		2	3	4	4		1	2	2	2					2
DRINKING WATER QUAL.		1	2	3	3		1	1	1	1					
PUBLIC SAFETY								2	2						
VISUAL RESOURCE		2	3	4	4		2	2	2	2				1	
RECREATION		1	2	4	4		1	1	1	1				1	

[1]Alternatives' degree of effectiveness in addressing concerns by Citizens Committee

1 - Incidental
2 - Slight
3 - Moderate
4 - High

Table 2e.—Alternative Display

Objective	Plan Element		Economic Development	Environmental Quality	Social Well Being	Irreversible or Long Term Effect	Short Term Effect
Fluvial Sediment Reduct.	Alt 1	Present Condition	$1,000,000[1] ongoing program	409,275 Tns. sediment added to streams	Increased production cost	50-year cont. degradation of water	
	Alt 2	Stabilize 11 miles channel	$453,000 devel. Veg. & riprap channel	reduce 2,805 Tns. Sed.	Reduced crop production cost	riprap 9 miles	construction sediment
	Alt 3	Stabilize 36 miles	$975,000 Veg. & riprap channel	reduce 7,580 Tns. Sed.	Reduced crop production cost	riprap 26 miles	construction sediment
	Alt 4	Stabilize 71 miles channel	$1,380,000 Veg. & riprap channel	reduce 12,795 Tns. Sed.	Reduced crop production cost	riprap 41 miles	construction sediment
	Alt 5	Stabilize 105 miles channel	$1,566,000 Veg. & riprap channel	reduce 15,682 Tns. Sed.	Reduced crop production cost	raprap 51 miles	construction sediment
Erosion Reduct.	Alt 1	Present Condition	$800,000 ongoing program	420,000 Tns. Soil lost offsite	Loss of forest range productivity	40-yr. cont. soil loss	
	Alt 2	Revege. 16,734 acres	$681,000 revegetation	reduce 2,650 Tns. Soil	Higher production forest & range		
	Alt 3	Revege. 83,188 acres	$1,625,000 revegetation	reduce 12,711 Tns. Soil	Higher production forest & range		
	Alt. 4	Revege. 104,249 acres	$2.880,000 revegetation	reduce 20,945 Tns. Soil	Higher production forest & range		
Flood Damage	Alt. 1	River Bank Protection	Protect Prime Land $ 88.500	Alter bank appearance Maint. Orchard	Maintenance jobs	Rock riprap 2,950'	const. sed. in stream
	Alt. 2	Const. Dikes	$560,000	Visual Alteration	Alleviate flood protect 84 a. orchard	loss of 126 acres agricultural land	
	Alt. 3	Channel Clear	Not Estimated		Alleviate flooding		sediment in stream
Single Purpose	Alt 1	Protect Irrigation	Rainey Collector $ 39,000	No improvement in Erosion or Sediment	$278,000 reduction in annual O&M costs		
	Alt 2	Entiat Mouth	Rec. Dev. - day use Imp. fish passage	Visual enhancement	Improve access to river	Structure in river	
	Alt 3	Fish Spawn	Enhance fishery - Imp. Spawning habitat			Structure in channel	

[1]Dollar amounts in terms of 1978 dollar

Program Selection

This Study attempts to:

- Quantify Basin problems,
- Show problem relationships,
- Display a set of alternative solutions that address problems to varying degrees, and
- Identify priority areas needing treatment.

Presentation and use of this Study to establish a community-supported program is the next step. Table 3 shows agency assistance which may be available to landowners for solution of problems. Individual agency programs are discussed in Section V of this report. Sources of agency assistance are identified and related to program elements. This report can form the basis for development of specific project plans by private citizens and agencies. Alternative elements can be used to form a concerted effort to address problems in the upper Watershed and on the valley's agricultural lands.

The selected program should strike a balance between:

- Long-range solutions,
- Providing for immediate needs, and
- Short-range solutions.

It should also:

- Direct funds to priority areas,
- Consider social well-being objectives as well as financial ones,
- Be designed to meet a range of objectives established by the community,
- Recognize the cause and effect relationship of problems, and
- Assure that the objectives of any remedial measure are clearly identified so that benefits can be quantified.

Table 3.—Agency Assistance Available to Landowners for Solution of Problems in the Entiat River Basin[1]

	DEPARTMENT OF AGRICULTURE										Washington State	
	SCS	SCS-FS PL566[2]	SCS-FS RC&D[2]	FS (Thru DNR)	FmHA	ASCS (ACP)	CES	ESCE	HUD	Army COE	DOE	CD
SOIL EROSION												
Crop & Range	T	$,T	$,T		C	$	E	S			R	L,E
Forest	T	$,T	$,T	$,T	C	$	E	S			R	L,E
FLOODING	T	$,T	$,T		C	$	E	S	I	$,T	P,R	L,E
CHANNEL STABILIZATION	T	$,T	$,T	T	C	$	E	S		$,T	P,R	L,E
SEDIMENT IN IRRIGATION												
Sed. Ponds												L,E
Filters	T	$,T	$,T		C	$	E	S				
Rainey Coll.												
Well Const.	T	$,T	$,T		C	$	E	S			PR,	
FIRE Forest-Range				$,P,T,E								L,E
WATER QUALITY	T	$,T	$,T	T		$	E	S			P,R	L,E
NATURAL DISASTERS	$,T	T		$,T	C	$	E				P	L,E

Legend:
- T = Technical Assistance
- $ = Financial Assistance
- L = Local Direction
- E = Education & Information
- R = Regulation
- P = Planning & Operations
- C = Farm Loans
- S = Research
- I = Insurance

SCS - Soil Conservation Service
FS - Forest Service
FmHA - Farmer's Home Administration
ASCS - Agricultural Stabilization & Conservation Service
(ACP) (Agricultural Conservation Program)
CES - Cooperative Extension Service
ESCS - Economics, Statistics & Cooperatives Service
HUD - Housing & Urban Development
COE - Corps of Engineers
DOE - Department of Ecology
CD - Conservation District
DNR - Department of Natural Resources

[1]See Chapter 5 for a discussion of these programs.

[2]These programs are not currently in the Basin. Opportunity exists, but is not high. See discussion, Chapter 5.

Use of this Report

This study Report can be used in two ways.

To formulate a program which is coordinated and jointly agreed upon.

As a basis or supporting document for project planning.

Several tools are provided to help in the development of a concerted program. The most significant of these include the following:

Stream Channel Stability Map — used to direct remedial work to reaches contributing most to the instream sediment problem.

Land Erosion and Sediment Yield Map — used to direct remedial work to land areas with the highest erosion rates.

Critical Erosion and Rehabilitation Needs Map — used with both the above maps to focus on specific inventoried needs.

The alternatives

Since viable solutions will probably be a mix of selected elements from several of the presented alternatives, no one alternative is recommended.

The displayed Erosion and Sediment Reduction Alternatives are points on a continuum. Therefore, they can serve as a reference point with respect to the cost and effectiveness of the selected program.

This study shows that instream sediment is the cause of problems affecting irrigation, fish spawning, water quality, channel capacity, bank erosion, etc. (Figure 1). Consequently, reduction of sediment will alleviate all of these problems.

This study also shows that 72 percent of this instream sediment derives from lower bank and channel erosion.

Priorities for Action

Generally the premise should be that until sediment entering stream systems is significantly reduced, all downstream measures will be short-term solutions.

The Corps of Engineers, for instance, considers stream channel clearance to be a temporary improvement which will last only until high runoff brings down another load of sediment and debris. If the Entiat Mouth were dredged, sediment carried by the stream would rapidly eliminate any gains in depth. Artificial spawning channels or gravel clearing could be covered quickly following heavy runoff. However, sediment reduction takes time, and temporary treatment of banks, channels, and spawning will probably be desirable and profitable.

Setting specific priorities for action is difficult because the objectives of community members differ. The fisheries biologist, orchardist, forest land manager, as well as others, each has an opinion of what should be done first. In all probability, the program resulting from community discussion will contain elements addressing several objectives.

Long-Range Solutions

Reduce sediment entering the stream system. Work on areas upstream of Stormy Creek to benefit agricultural areas and the best anadromous fish spawning.

1. Treatment of channels and lower banks within reaches having a very poor stability rating.

2. Treatment of upland areas to reduce runoff and overland flow. Use Land Erosion and Sediment Yield Map and Critical Needs Map.

Provide for immediate needs — short-range.

1. Protect eroding streambanks fronting prime orchardland and improvements.

2. Alter irrigation systems to intercept sediment.

3. Channel clearing and snagging to remove deflectors and increase capacity.

The action plan decided upon could be a concerted effort involving stabilization of streambanks, removal of woody debris and perhaps some gravel bars from streams, and land treatment to reduce overland flow and runoff. While these efforts will, with time, reduce instream sediment, it will still be desirable to riprap to protect prime orchardland, intercept sediment before reaching irrigation sources, enhance spawning or take other steps which are perhaps temporary, but will effect immediate relief from the symptoms of instream sediment.

In any program the cause and effect relationship depicted in Figure 1 should be a guide to work priority Program selection criteria such as those suggested on Page 17 should be followed.

The Visual Resource, a stated community concern, should not be overlooked. A guide for managing the visual resource of the Entiat Corridor is available. Visual objectives should be considered from the outset of project planning.

Organization to carry out a plan

A mechanism to put forward a concerted program is needed. It is recommended that an established group such as the Chelan Conservation District assume the coordination role to sponsor preparation of a community program. An Ad Hoc Committee including representatives of the Wenatchee National Forest, Soil Conservation Service, and Agricultural Stabilization and Conservation Service would form the nucleus. The State Department of Fisheries, U.S. Fish and Wildlife Service, Corps of Engineers, Chelan County P.U.D., and others would be consulted as needed and would serve as a program review group.

The developed program must be one to which the agencies involved are committed. Project planning will occur within each agency for their particular jurisdiction. However, each agency's program needs to be compatible with others. No effective sediment damage reduction program can succeed without each entity doing its part.

Funding requests by agencies and individuals should be made in the context of their part in the community program.

Chapter 1—Description of the Entiat Basin

General

The Entiat River Basin is located in north-central Washington State in Chelan County. The River heads in a glaciated basin near the crest of the Cascade Mountains and flows southeasterly. It meets the Columbia River near the town of Entiat, about 20 miles upstream from Wenatchee. For about half of its length the River is within the administrative boundary of the Entiat Ranger District, Wenatchee National Forest. There are two major tributary drainages within the Entiat Basin. These are the North Fork Entiat which joins the Entiat at River Mile 33 and the Mad River which enters at River Mile 10.5.

The Entiat system drains an area of about 416.5 square miles. The Watershed is nearly 42 miles in length and varies in width from 5 to 14 miles. It is bounded on the northeast by the Chelan Mountains and on the southwest by the Entiat Mountains. The Chelan Mountains begin as a ridge extending eastward from the Cascade Summit near Glacier Peak. The Entiat Mountains branch off from this ridge in a southeasterly direction. The Chelan Mountains continue east a few miles then they too bend toward the southeast.

A rim of snow-covered peaks supply the Entiat's headwaters. These include Buckskin, Tinpan, and Pinnacle Mountains; Mt. Maude; Seven Fingered Jack; and Mt. Fernow. The Basin's highest elevation is the 9,249 foot summit of Mt. Fernow. The Basin's lowest elevation is approximately 700 feet at the River's confluence with the Columbia.

The glacier-carved Entiat Valley looking downriver from Fox Creek. Fox Creek flows from a hanging valley and crosses an alluvial fan before it joins the Entiat.

Geomorphology

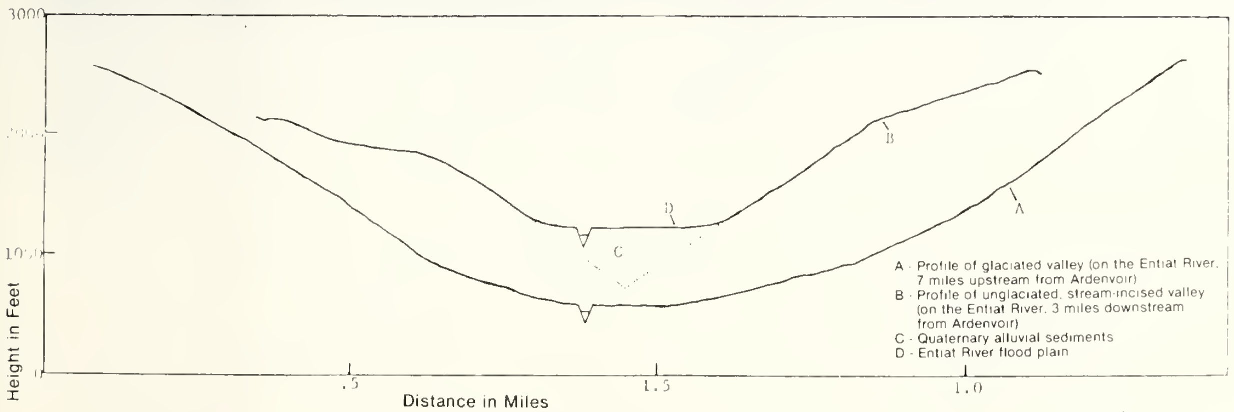
In the North Cascades deformation processes have produced complex structural features. Extensive folding and faulting has occurred. A normal fault follows the west side of the Entiat Mountains. These mountains and the Chelan Range have been uplifted. The rocks of the northern Entiat Mountains are probably in the core of an anticline. A syncline may extend along the east flank of the Entiat Mountains. The Entiat Basin is apparently a depression between two uplifts, possibly a down-warped valley.

Three generations of topography are evident in the Entiat Basin. In the first generation, the rolling hills of the lower basin are indicative of a time when streams were downcutting slowly or not at all. The growth of the Cascades had not yet begun.

During the second generation, the Cascades began uplifting. This gave the streams greater erosive power. Narrow canyons were incised into the rolling hills. The rock and soil carved from these canyons were dumped on alluvial fans where the streams met the Entiat River flood plain. Most of the sediment transport occurred during periods of high streamflow. This is an ongoing process. It will be perpetuated by the slow but continuing uplift of the land and the relative instability of the sparsely vegetated soil.

The third stage of evolution has affected the topography of only the Upper Entiat. Alpine glaciation has created hanging valleys, moraines, U-shaped valleys, and made such great modifications that the previous topography is unrecognizable. During the Pleistocene Epoch a valley glacier nearly 25 miles long dominated the Entiat Basin. From its source on the flank of Mt. Maude, the glacier extended to Potato Creek, about 5 miles above the Ardenvoir townsite. Piles of rock and soil form a terminal moraine here indicating the farthest advance of the glacier. Above this moraine, the valley is the characteristic glacial U-shape blanketed by till. Below the moraine, the main valley and tributaries are a typical stream-incised V-shape (Figure 2). The Entiat River Valley is further modified by a broad floodplain in which lies water-stratified silt, sand, gravel, and cobbles (photo).

Figure 2.—Cross-sectional Profiles of Glaciated and Unglaciated Portions of the Entiat River Valley

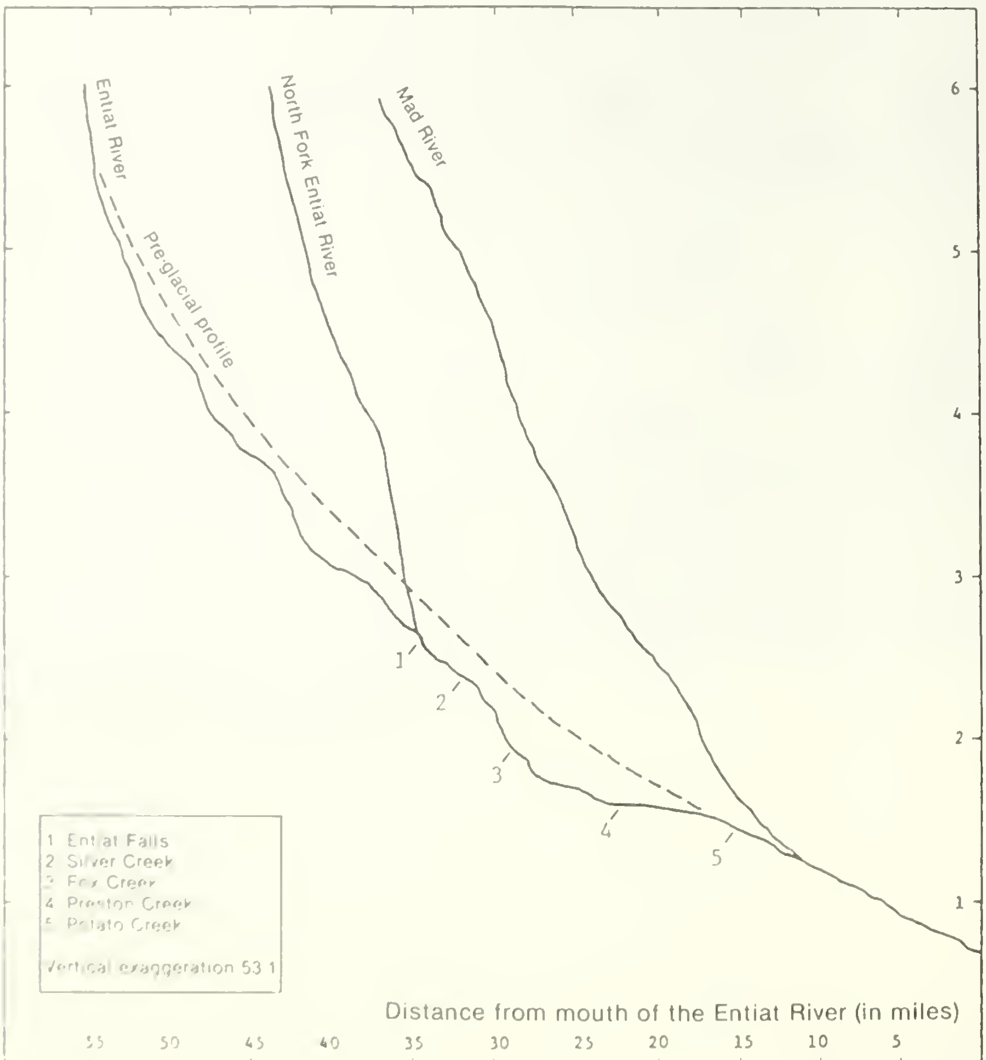


The upper Entiat River descends in a series of riegels (steps) and basins formed by the quarrying effect of the glacier (Figure 3). The glacier's greatest erosive force is exerted near its terminus, thus on the Entiat the largest basin lies between Silver Creek and Potato Creek, the furthest point of glaciation. Deviation from an estimated preglacial stream curve is greatest here (Figure 3). The stream gradient drops from an average of 2.3 percent to less than 0.3 percent, the River begins to meander on a broad flood-plain, and the Basin acts as a catchment which collects sediment brought down from the upper watershed.

The Study area conforms to the watershed boundary of the Entiat River and its tributaries which drain into the Columbia River. The Entiat River begins as meltwater from the Entiat Glacier on Mt. Maude. Major perennial tributary streams of the Entait River include the North Fork of the Entiat, Ice Creek, Snowbrushy Creek, Mad River, Pope, Lake, Stormy, Preston, and Mud Creeks. The majority of the remaining streams are intermittent and flow only during snow-melt periods and during concentrated summer rainstorms.

Several tarns (glacial lakes) are present in the area. These include Ice Lakes (two), Larch Lakes (two), Myrtle Lake, Choral Lake, Fern Lake, and several small lakes in the Klone Peak area.

Figure 3.—Stream Channel Profiles of the Entiat, North Fork Entiat, and Mad Rivers



The watershed exhibits both dendritic and trellis drainage patterns. The trellis pattern is clearly shown along the glaciated portion of the Entiat River and its glaciated tributaries. This pattern is a result of spur truncation by glacial scouring. This left the tributaries "hanging" and they now enter the major streams at nearly right angles.[2]

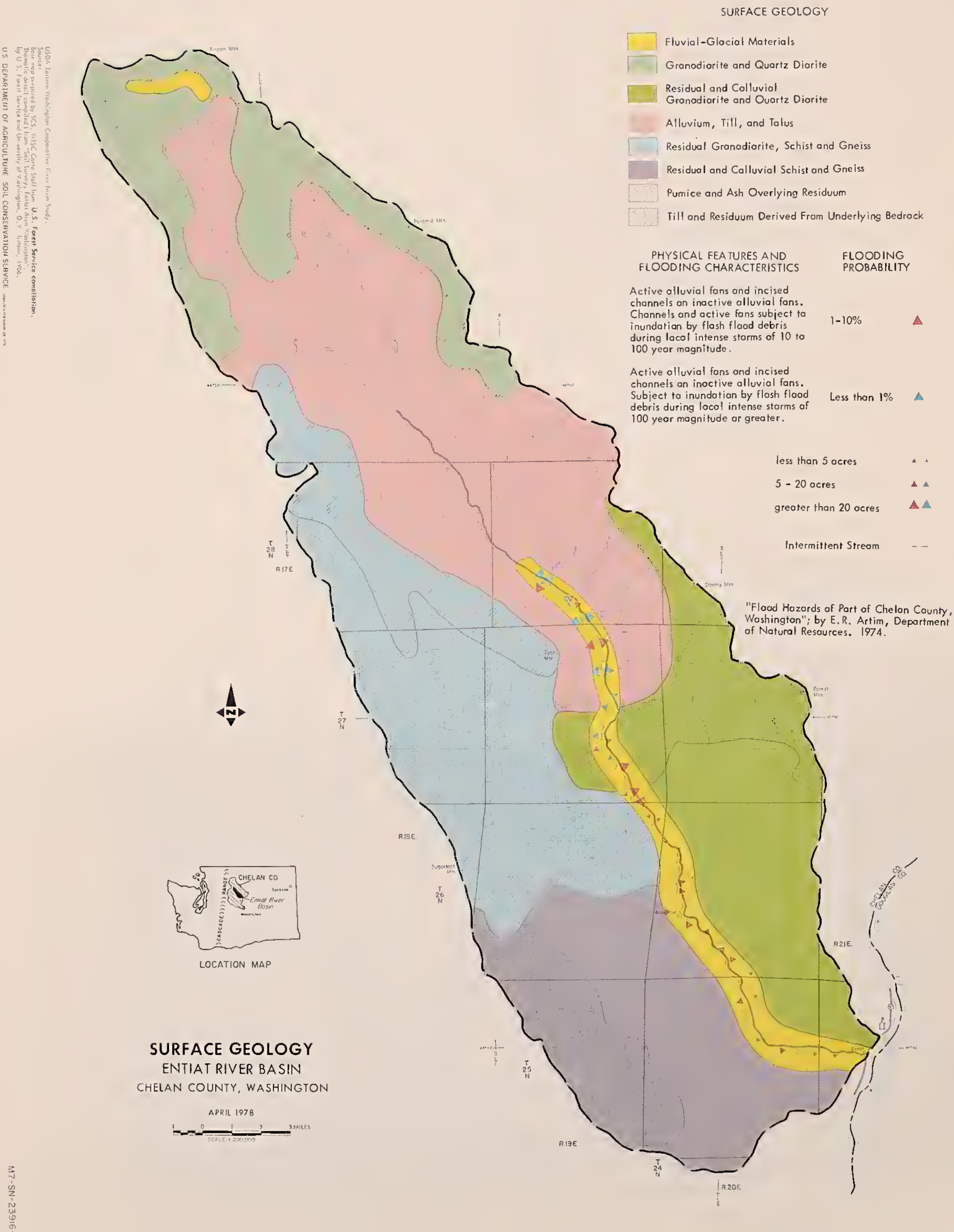
**Data source note found on page 133.*

Geology

The Entiat River Basin is composed primarily of metamorphic schist and gneiss, intrusive granodiorite, and quartz diorite. The Chelan and Entiat Ranges consist of ragged angular forms indicative of hard rocks. They are predominantly quartz diorite and granodiorite with lesser amounts of schist and gneiss. Some areas are traversed by more resistant dikes of rhyolite porphyry. Mt. Maude and Seven Fingered Jack are massive quartz diorite formations. Spectacle Buttes, at the head of the Basin, are portions of an exposed quartz diorite/gneiss pluton.

Major geologic formations include Swakane Gneiss, Chiwaukum Schist, and Mt. Stuart Granodiorite. Swakane Gneiss is the oldest and is composed of mediumgrained gneiss, coarse amphibolite schist, and many small stringers of pegmatite and mylonite. Chiwaukum Schist contains foliated rocks ranging from phyllite to fine gneiss. Mt. Stuart Granodiorite (Jurassic) consists of medium- to coarse-grained gray granodiorite containing abundant biotite and some hornblende. This formation is often highly weathered where exposed.

Most of the area is covered by volcanic ash and pumice which was blasted from Glacier Peak at intervals within the past 12,000 years. This now dormant volcano is 25 miles west of the survey Basin.[3] Prevailing winds carried the pyroclastic debris; therefore, the amount of deposition is related to distance from Glacier Peak and topographic aspect. Pumice and ash blankets most of the Basin, north and east facing slopes having the deepest deposits. In some places these deposits are deep enough to obscure the underlying bedrock (see Surface Geology and Flood Hazards Map).

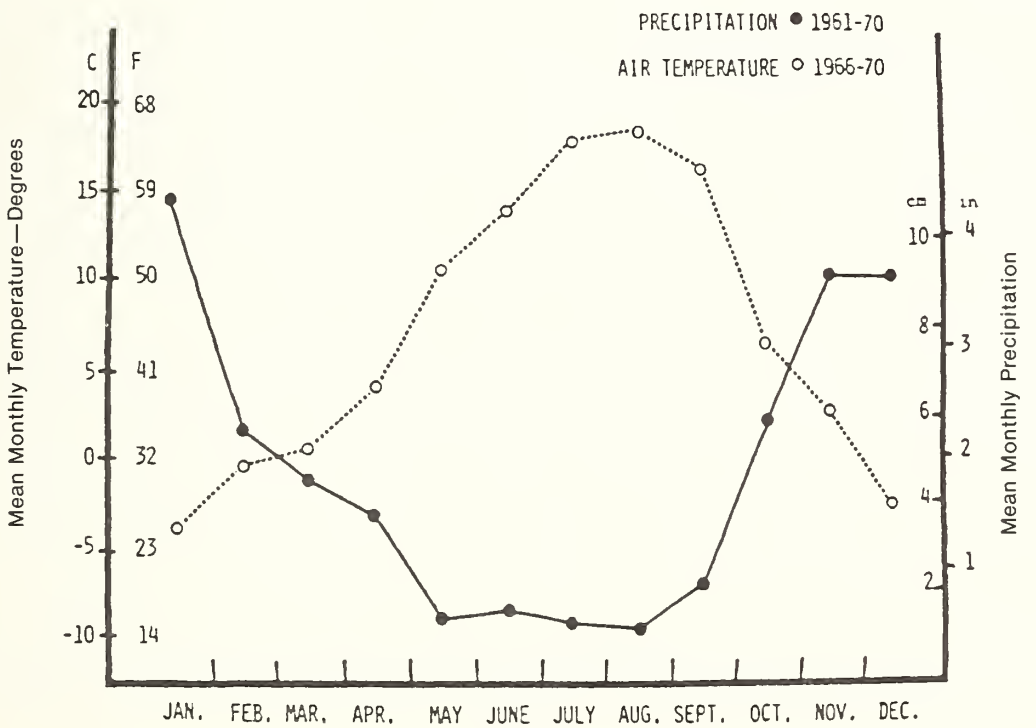

SURFACE GEOLOGY
Fluvial-Glacial Materials
Granodiorite and Quartz Diorite
Residual and Colluvial Granodiorite and Quartz Diorite
Alluvium, Till, and Talus
Residual Granodiorite, Schist and Gneiss
Residual and Colluvial Schist and Gneiss
Pumice and Ash Overlying Residuum
Till and Residuum Derived From Underlying Bedrock
PHYSICAL FEATURES AND FLOODING CHARACTERISTICS
FLOODING PROBABILITY
Active alluvial fans and incised channels on inactive alluvial fans. Channels and active fans subject to inundation by flash flood debris during local intense storms of 10 to 100 year magnitude.
1-10%
Active alluvial fans and incised channels on inactive alluvial fans. Subject to inundation by flash flood debris during local intense storms of 100 year magnitude or greater.
Less than 1%
less than 5 acres
5 - 20 acres
greater than 20 acres
Intermittent Stream
"Flood Hazards of Part of Chelan County, Washington"; by E.R. Artim, Department of Natural Resources. 1974.
T 28 N
R17E
T 27 N
R18E
T 26 N
T 25 N
R19E
T 24 N
R20E
R21E
CHELAN CO
DOUGLAS CO
CHELAN CO
CASCADE RANGE
Entiat River Basin
LOCATION MAP
SURFACE GEOLOGY
ENTIAT RIVER BASIN
CHELAN COUNTY, WASHINGTON
APRIL 1978
3 MILES
U S DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE
M7-SN-23916-3

Climate

Climate in the Entiat Basin varies from that characterized by arid grassland at the lowest elevations to moist alpine type at the higher elevations. Mean annual precipitation correspondingly ranges from about 90 inches to less than 10 inches due to the rain-shadow effect of the Cascades. Prevailing winds move moisture-laden air easterly up the windward slope of the west Cascades. This orographic lifting produces heavy precipitation on the west slopes and near the summit. Air descending along the leeward slope is warmed by compression thereby sharply decreasing precipitation.[4]

Most of the winter precipitation falls as snow; however, rain is not unusual. In an average winter, snowfall ranges from less than 50 inches at the lower elevations to nearly 400 inches on the peaks where depths may reach 10 to 20 feet and remain on the ground from mid-November until June. During summer, thunderstorms frequently develop over the mountains resulting in heavy downpours for brief periods. Occasionally, these heavy showers produce flash floods at the mouths of narrow canyons.[2] Approximately 50 percent of the mean annual precipitation falls between October and January and 75 percent falls between October and March. The total precipitation for the two driest months, July and August, is from 5 to 10 percent of the annual.

Figure 4.—Average monthly values · precipitation and temperature 3,000-foot (915-m) elevation on the Burns Creek Watershed.[26]



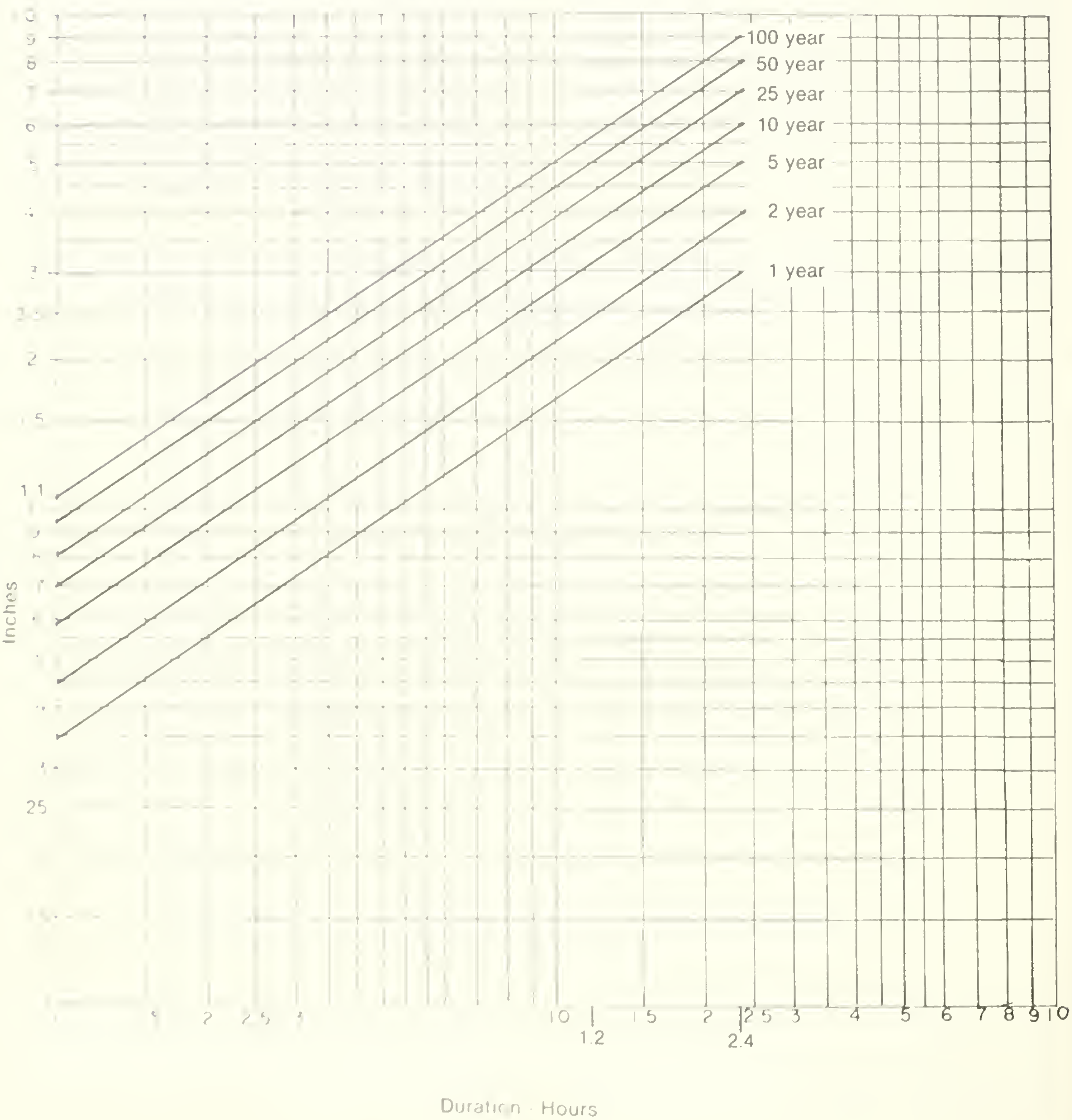
During the summer, temperatures in the lower Entiat Basin usually range between 60 and 70 degrees, decreasing to the 50's at higher elevations. In the lower valley, temperatures in the 90's frequently occur during July and August. The growing season in the agricultural areas averages 150 days. In winter, weather systems moving east from the Pacific and outbreaks of cold air from Canada produce frequent changes.[4] During an average winter, temperatures range from 15 to 30 degrees with elevation.

Figure 5.—Entiat Rainfall Frequency · Forest Lands

Durations = 1 Hour to 24 Hours

Return Periods = 1 to 100 Years

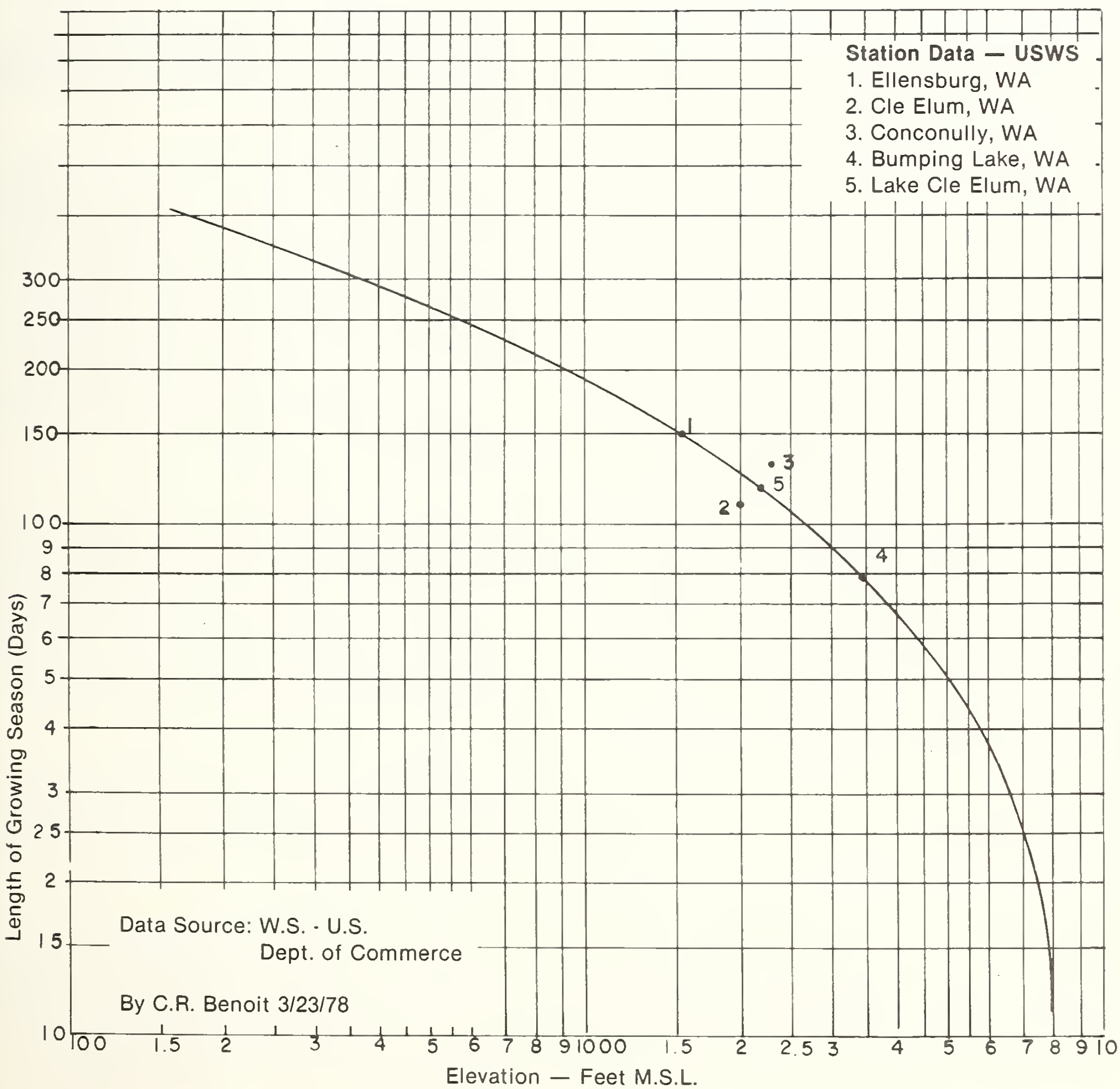
Data Base: USDC T.P. 40



The date of the last frost in the lower valley at Entiat is about May 1, however, they have occurred as late as May 15. The first frost of the fall is likely to occur about October 1. Every other location in the Entiat River Basin, due to higher elevation, will have a shorter frost-free season than the Entiat Valley at Entiat.

The average growing season (days above 60 degrees F.) ranges from about 150 days in the Entiat Valley at the confluence of the Columbia River to less than 80 days at the 3,500 foot elevation level. Figure 6 is a relationship between days of growing season and elevation based on local long-term U.S. Weather Service data.

Figure 6.—Relation Between Elevation and Days of Growing Season
(Day Temperature >60°F)



Historical Development

The purpose of this section is not to relate the entire history of man's activity in the Basin but rather to highlight those events which bear on the problems the Basin faces today.

A portion of these problems are attributable to natural geologic processes and the effects of a comparatively young river carving a place for itself. These processes were occurring before man's intrusion into the valleys of the Entiat. The first men were the Indians who camped, fished, and hunted there. It was from them that the early settlers derived the River's name. Erosion and sedimentation from natural processes were soon supplemented by that caused from use of the land.

The grazing of livestock probably began in the late 1800's. Each settler had a few head of cattle and horses which grazed freely. Even hogs were grazing in the foothills by 1900 and sheep were herded to the Basin's upper reaches. At its height it has been estimated that 1,000 head of cattle and 400 horses grazed nearly year-long between the town of Entiat and Stormy Creek. As many as 13,000 sheep ranged the Basin and 150 hogs uprooted large areas in the foothills [5]

The destruction of vegetation certainly had a measurable effect on the streams of the Entiat.

Fire has also played a continuing part in the Basin's development by destroying the Basin's water and soil-holding vegetation. The cool air descending from the Cascade Crest meeting the warm air rising from the Columbia Valley creates thunderstorms which start a good share of the fires each year. Here again, the forces of nature are supplemented by man's activity. There are no written records of fires started by Indians but almost certainly man-caused fires increased at first in proportion to the land clearing for homes and farms, then with grazing use and later, logging.

There are some large fires of record which caused extensive damage to watershed vegetation. For instance, a fire in the 1880's burned most of the Mad River Gorge up to Blue Creek Meadows.[6]

Another large fire in July 1910 burned 2,560 acres from the Entiat River to the ridge between Signal and Tyee Peaks and including Grandma Creek. Then in August 1914 approximately 600 acres of forest at the mouth of Burns Creek were destroyed.

Intensifying use was not unique to the Entiat. National concern for protection of Federal lands withdrawn by Congress, which included the Washington Forest in 1902, led to the creation of the National Forest in 1907.

Grazing continued to be the chief use of the new National Forest. With the coming of restrictions, grazing pressure steadily declined. The first allotment, Potato Creek, was established in 1926.

Timber harvest played an ever increasing role in the Basin on private lands belonging to Northern Pacific Railroad Company and National Forest lands.

Flooding in 1948, the worst on record, caused severe flood damage and erosion, from the town of Ardenvoir to the mouth. More recently, flooding and stream-bank erosion occurred in June 1972 when the River reached flows of 6,840 c.f.s. as melt from a record snowpack in the winter of 1971-72 combined with heavy rainfall. Runoff in the Basin on June 10, 1972, caused landslides on Preston Creek, tributary to the Entiat River, taking four lives. Again in 1974, spring runoff was above normal causing severe bank erosion over the entire Basin.

The most recent (since those of 1970) large fire, Crum Canyon, began on private land July 24, 1976, and spread northeast with one arm extending southeast reaching close to the town of Entiat. It was apparently man-caused and burned 3,000 acres of grass and forest land within the Basin before it was contained July 27. The total burn area, including lands outside the Entiat Basin was 9,000 acres.

A storm event occurred June 13, 1977. Rain intensities were heavy with 4 to 6 inches of hail deposited within less than 1 hour. Flooding resulted with peak flows of 4,000 c.f.s. emanating from Crum Canyon.

A second storm of similar intensity, over much of the same area, followed July 25th. Flooding equaled or exceeded the first event with resultant extreme erosion.[1] The County road, fish hatchery, private homes and property, and forest and agricultural lands suffered heavy damage from

both events and the Entiat River received tons of sediment.

Significant runs of chinook salmon, coho salmon, and steelhead trout occurred in the Entiat River prior to 1898. The last sizable chinook run occurred in 1904 and very few fish remained by 1925. Stream surveys conducted in the 1930's found the River almost devoid of salmon.[7]

In 1939 and 1940 portions of the chinook and steelhead runs blocked by constructin of Grand Coulee Dam were transferred to the Entiat River.

The Entiat River was planted with steelhead smolts for the first time in 1964. These fish returned as adults 1 and 2 years later (e.g., 1965 and 1966). The steelhead planting program in the Entiat River, funded by Chelan PUD as part of the Rocky Reach Project mitigation, has ranged from 15,000 in 1964 to 58,000 in 1970. It has averaged about 30,000 to 35,000 smolts annually. Since the inception of steelhead planting, the angler catch has averaged 108 a year; the maximum 284, occurred in 1971.[8]

The Department of Game and later the Fish and Wildlife Service annually planted about 25,000 catchable trout. A fish hatchery was also constructed on the lower river in 1941. The Entiat Hatchery was returned to anadromous fish production in 1974 and should prove instrumental in rehabilitating the runs. Count difference between Rocky Reach and Wells Dams between 1968 and 1974 indicated possible Entiat River escapements of 700 to 1,800 spring chinook. Average escapement for this period was 1,122 fish.

Past Rehabilitation Efforts

Much has been accomplished since the 1970 fires to restore the Basin's hydrologic and ecologic equilibrium. Citizens of the Entiat have invested their own funds and time in efforts to limit streambank erosion and subsequent loss of orchard and homesites. There has also been a corresponding effort by a variety of local, State, and Federal agencies. The extensive vegetative loss of 1970 has increased the severity of subsequent runoff and storm events, often frustrating remedial efforts.

Following the August-September 1970 fires described previously, the Wenatchee National Forest began a comprehensive burn rehabilitation effort in October of that year. Emergency seeding was completed the following spring. The Entiat Basin contained less than 60 percent of the burned acreage, but approximately $450,000 was expended within the Basin on soil stabilization measures including stream cleanout and installation of trash racks, sediment check dams, and ponds. The Forest Service continued long-range rehabilitation including extensive reforestation. A tabulation of this work and reference to rehabilitation reports are in Appendix F. The fact that rehabilitation of the Burn was begun immediately undoubtedly significantly reduced the severity of the 1972 flood, even though much of the remedial work was lost to the heavy runoff.

In April 1971, the Corps of Engineers removed woody debris from approximately 10 miles of the Entiat River under authority of Section 208 of the 1954 Flood Control Act at a cost of $34,000. Both Federal and private lands were involved, and the Forest Service contributed $17,000 for work done on National Forest lands.

The Corps of Engineers also acted in 1972 to remove debris from the Entiat River and Preston Creek Slide Area under disaster assistance authority.

The Agricultural Stabilization and Conservation Service (ASCS) has been providing assistance to individuals in efforts to prevent further erosion of agricultural lands through cost share agreements. The Soil Conservation Service supplied technical assistance in the design and installation of streambank stabilization structures. In the fall of 1973 the ASCS entered into agreements with several individuals and a church camp group to share 50 percent of the installation cost. On nine separate projects, various work was done, including construction at two locations, of Class III dike consisting of more than 3,000 cubic yards of compacted earth-fill, providing protection to 40 acres of hay and pasture. Another project involved stream channel clearance needed to widen the River to prevent overtopping and erosion of riprap installed by the Corps of Engineers following the 1948 flood. More than 8,000 cubic yards of rock riprap was installed at nine separate sites including riprap by the U.S. Fish and Wildlife Service to protect the hatchery. Although work was initiated in the fall of 1973, it was not completed that year. The spring flood of 1974 destroyed some of the work which was done. This had to be redone, and the 1973 program was finally completed in 1975. Altogether the ASCS expended approximately $40,000 in cooperative funds. Private individuals matched that investment. It is estimated that during the period 1972 through 1974, Rural Environmental Conservation Program and Agricultural Conservation Program Practices were applied to 26 farms and consisted of approximately 6,000 feet of bank stabilization, 9,000 feet of clearing and snagging, and 8,000 feet of riprap.

In January 1976, the Soil Conservation Service prepared a report entitled *Preliminary Investigations, Entiat River Valley Group, Chelan County, Washington*. The report contains the cooperative working agreement for group conservation planning assistance, Chelan County Conservation District, for eight bank protection projects involving 11 landowners.

The Soil Conservation Service, working in cooperation with the ASCS, approved and funded a $10,000 allotment in Fiscal Year 1976 for two of eight projects covered by the January 1976 cooperative agreement. Work has been accomplished on one, and four others are now ready to begin construction when money is available.

As a result of the Crum Canyon fire of July 1976, the U.S. Forest Service applied emergency rehabilitation treatments to an additional 3,000 acres within the Basin. This work, including seeding, fertilization, debris removal, and land terracing, was completed in October 1976.

The twin storm events which hit this fire area in

June and July 1977 instigated a joint request by the Soil Conservation Service and Forest Service for watershed rehabilitation measures on private and public lands totalling 1.2 million dollars. These funds, received under the authority of Section 216 of the Flood Control Act of 1950, were allocated in May 1978 and work is currently underway.

Following the Crum Creek flood, Chelan County requested the Corps of Engineers to assist in restoring the Entiat Road which had washed out. The request was made June 17, 1977. The County then went ahead on its own to make temporary repair to the roadway embankment using material from the flood outwash cone. However, on July 26, a second storm flood washed out the temporary repairs. The Corps of Engineers, operating under authority of Section 14 of the 1946 Flood Control Act, accomplished bank protection work through a negotiated supply and rental equipment contract. Work was completed December 12, 1977. Along with this, approximately 10,800 cubic yards of sediment was removed from the river bed and spread at various sites away from the floodplains. Another 4,500 cubic yards was placed on the road fill and 2,500 tons of riprap were placed. Total cost was about $46,000.

Since the 1972 flood, two rehabilitation projects have been accomplished in the Entiat River. In 1973 the Washington Department of Fisheries cleaned approximately 9,000 square yards of gravel in the vicinity of Brennegan Creek.

The last effort to improve spawning conditions was completed in 1976. The Washington State Department of Fisheries, working jointly with the U.S. Forest Service, constructed a 300-foot spawning channel near Fox Creek. Although limited spawning activity was noted in 1976 because of the late completion date, the channel was utilized in 1977. Cost: $13,000 Forest Service funds and $25,000 State funds for a total of $38,000.

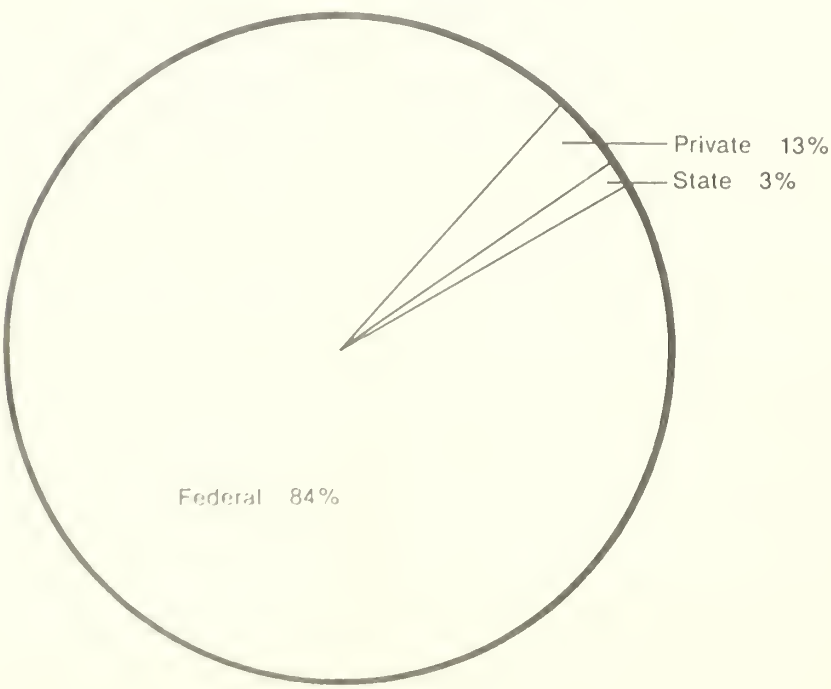
Ownership

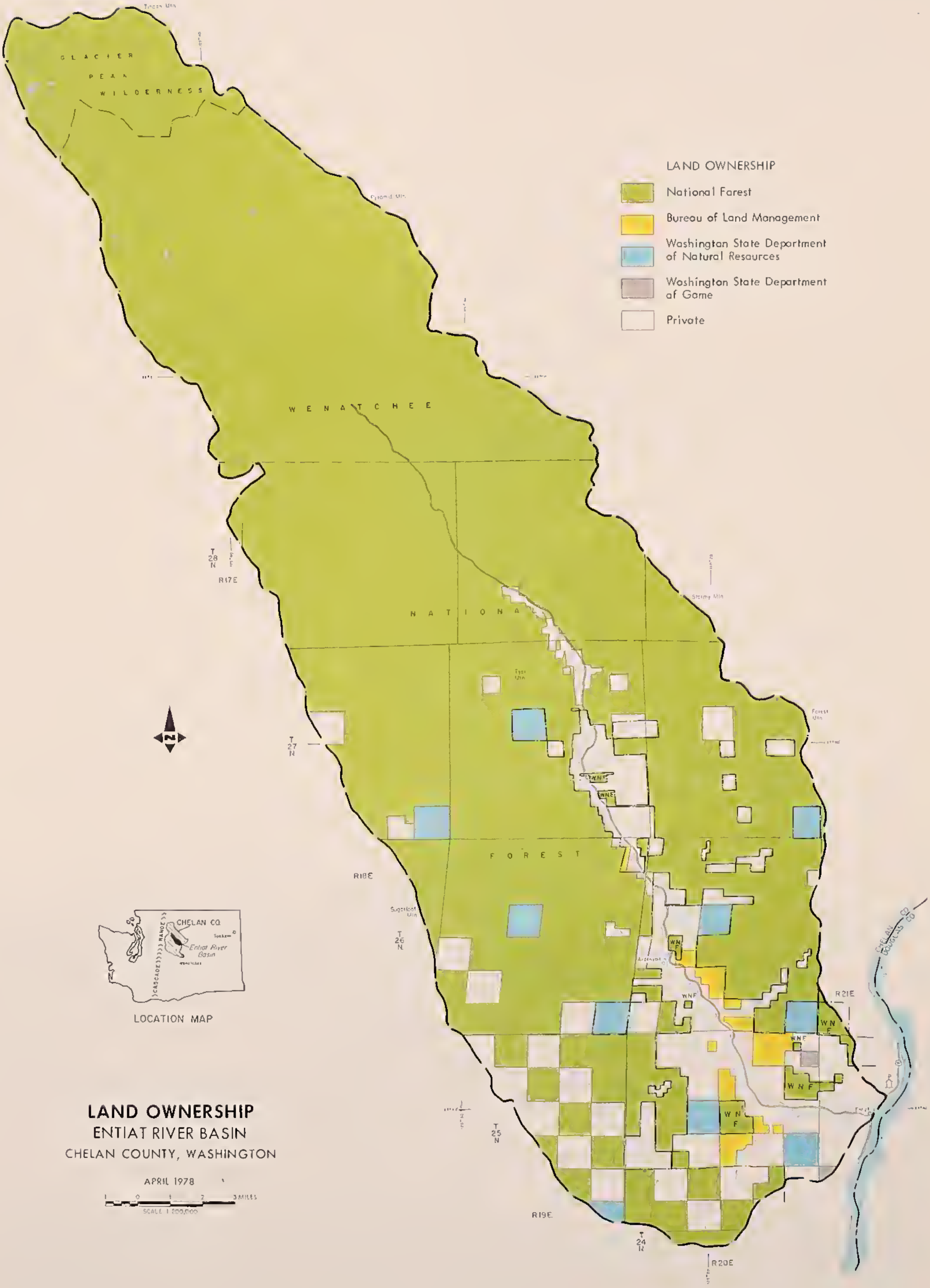
The present ownership pattern evolved from public domain, railroad land grants and subsequent sales, and exchanges creating isolated private parcels surrounded by public lands. Typically, the river floodplain invited transportation routes and settlement and the portion suitable for agriculture remains today in private ownership (see Ownership Map).

Table 4.—LAND OWNERSHIP, ENTIAT BASIN

	Acres
National Forest	220,650
Private	34,885
Washington State (Dept. of Natural Resources)	8,080
Bureau of Land Management	2,560
Washington State (Game Dept.)	320
U.S. Fish and Wildlife Service	5
	266,500

Figure 7.—Land Ownership by Major Categories Federal, Private, State





U S D.A. Eastern Washington Cooperative River Basin Study

Source:
Base map prepared by SCS, WTSC Carto Staff from U.S. Forest Service compilation.
Thematic detail compiled by U.S. Forest Service.

M7-SN-23916-2

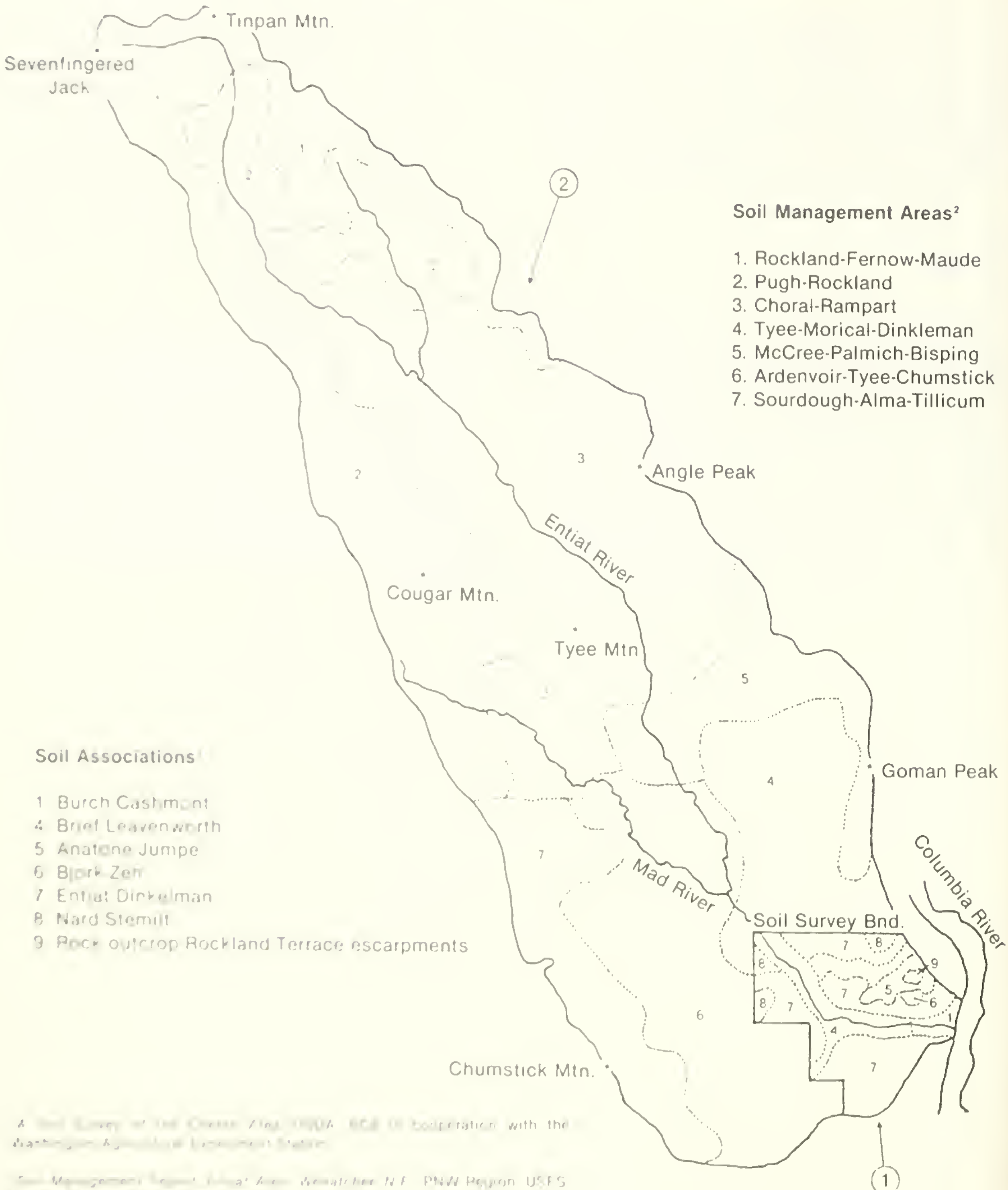
Natural Resources

The following discussion of the Entiat's natural resources is intended to briefly describe these resources, their use, and the values which are jeopardized by the problems afflicting the Basin. Resource use and management are factors which may contribute to or provide a partial solution to problems of erosion and sedimentation.

Soils

Basin soil resources are described in two separate reports. A soil survey of Chelan Area, Washington, by the Soil Conservation Service covers the lower Entiat Valley including most rangeland and irrigated agricultural lands. The remainder of the Basin, mostly forest lands, is discussed in the Forest Service's Soil Management Report, Entiat Area. There are some differences in the presentation of the findings of the soil scientists involved. However, in addition to detailed soil descriptions, both reports display soil associations which are useful for planning. These soil surveys were used as one basis for the hydrologic analysis contained in this Report. The soil associations were also used in agricultural and economic analyses. Associations or, as in the Forest service report, soil management areas, consisted of one to three soil types which occur together in a landscape in a distinct pattern. A brief discussion of these is in Appendix K. Figure 8 shows the soil management areas and associations as described in the two reports.

Figure 8.—Soil Management Areas & Soil Associations



Soil Management Areas[2]

1. Rockland-Fernow-Maude
2. Pugh-Rockland
3. Choral-Rampart
4. Tyee-Morical-Dinkleman
5. McCree-Palmich-Bisping
6. Ardenvoir-Tyee-Chumstick
7. Sourdough-Alma-Tillicum

Soil Associations[1]

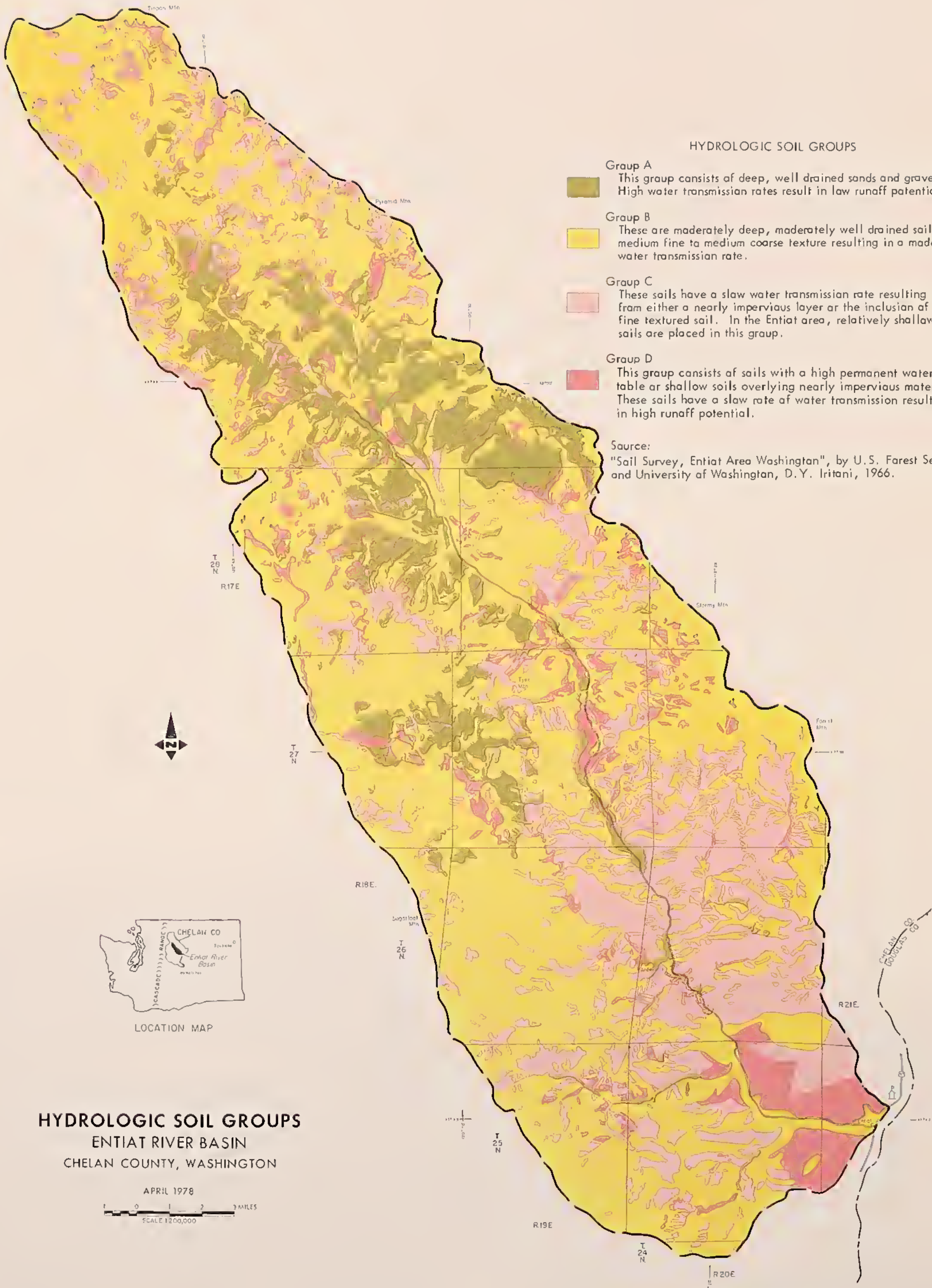
1 Burch Cashmont
4 Brief Leavenworth
5 Anatone Jumpe
6 Bjork Zen
7 Entiat Dinkelman
8 Nard Stemilt
9 Rock outcrop Rockland Terrace escarpments

[1] [illegible] in cooperation with the [illegible]

[2] Soil Management [illegible] PNW Region, USFS [illegible]

Source:
Base map prepared by SCS, WTSC Carto Staff from U.S. Forest Service compilation.
Thematic detail compiled by U.S. Forest Service.
U.S.D.A. Eastern Washington Cooperative River Basin Study

U S DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE



HYDROLOGIC SOIL GROUPS

Group A
This group consists of deep, well drained sands and gravel. High water transmission rates result in low runoff potential.

Group B
These are moderately deep, moderately well drained soils with medium fine to medium coarse texture resulting in a moderate water transmission rate.

Group C
These soils have a slow water transmission rate resulting from either a nearly impervious layer or the inclusion of fine textured soil. In the Entiat area, relatively shallow soils are placed in this group.

Group D
This group consists of soils with a high permanent water table or shallow soils overlying nearly impervious materials. These soils have a slow rate of water transmission resulting in high runoff potential.

Source:
"Soil Survey, Entiat Area Washington", by U.S. Forest Service and University of Washington, D.Y. Iritani, 1966.

LOCATION MAP

HYDROLOGIC SOIL GROUPS
ENTIAT RIVER BASIN
CHELAN COUNTY, WASHINGTON

APRIL 1978

SCALE 1:200,000 — MILES

M7-SN-23916-10

POTENTIAL SURFACE EROSION HAZARD

Low-
Surface soil loss and problems of erosion control are generally minimal. These soils exhibit the following characteristics: gentle slopes, strong structure, good permeability and deep sola.

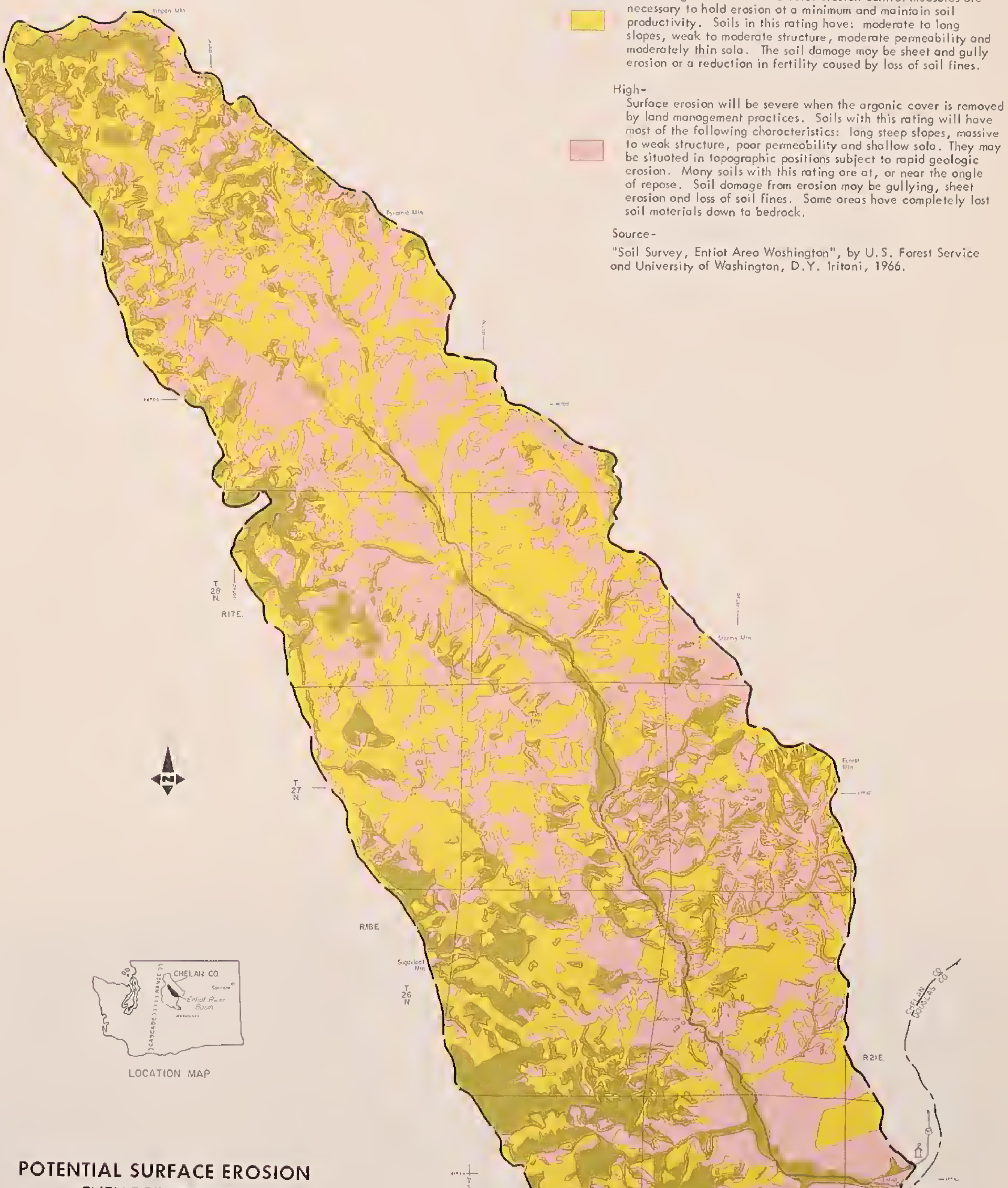
Moderate-
This rating indicates that careful erosion control measures are necessary to hold erosion at a minimum and maintain soil productivity. Soils in this rating have: moderate to long slopes, weak to moderate structure, moderate permeability and moderately thin sola. The soil damage may be sheet and gully erosion or a reduction in fertility caused by loss of soil fines.

High-
Surface erosion will be severe when the organic cover is removed by land management practices. Soils with this rating will have most of the following characteristics: long steep slopes, massive to weak structure, poor permeability and shallow sola. They may be situated in topographic positions subject to rapid geologic erosion. Many soils with this rating are at, or near the angle of repose. Soil damage from erosion may be gullying, sheet erosion and loss of soil fines. Some areas have completely lost soil materials down to bedrock.

Source-
"Soil Survey, Entiat Area Washington", by U.S. Forest Service and University of Washington, D.Y. Iritani, 1966.

Source-
Base map prepared by SCS, WTSC Carto Staff from U.S. Forest Service compilation.
Thematic detail compiled by U.S. Forest Service.
U.S.D.A. Eastern Washington Cooperative River Basin Study

US DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE



LOCATION MAP

POTENTIAL SURFACE EROSION
ENTIAT RIVER BASIN
CHELAN COUNTY, WASHINGTON

APRIL 1978

1 0 1 2 3 MILES
SCALE 1:200,000

M7-SN-23916-6

Water Use

The Entiat Watershed supplies water for the irrigation, industrial, and domestic needs of the Entiat Valley. This Study did not examine the chemical or nutrient quality of the Entiat's waters. However, the following statement, from the Columbia-North Pacific Framework Study (Appendix V. Water Resources), may be useful in comparing water quality with that of pre-1970 Basin conditions. Also see Problems (Hydrologic Analysis) Section.

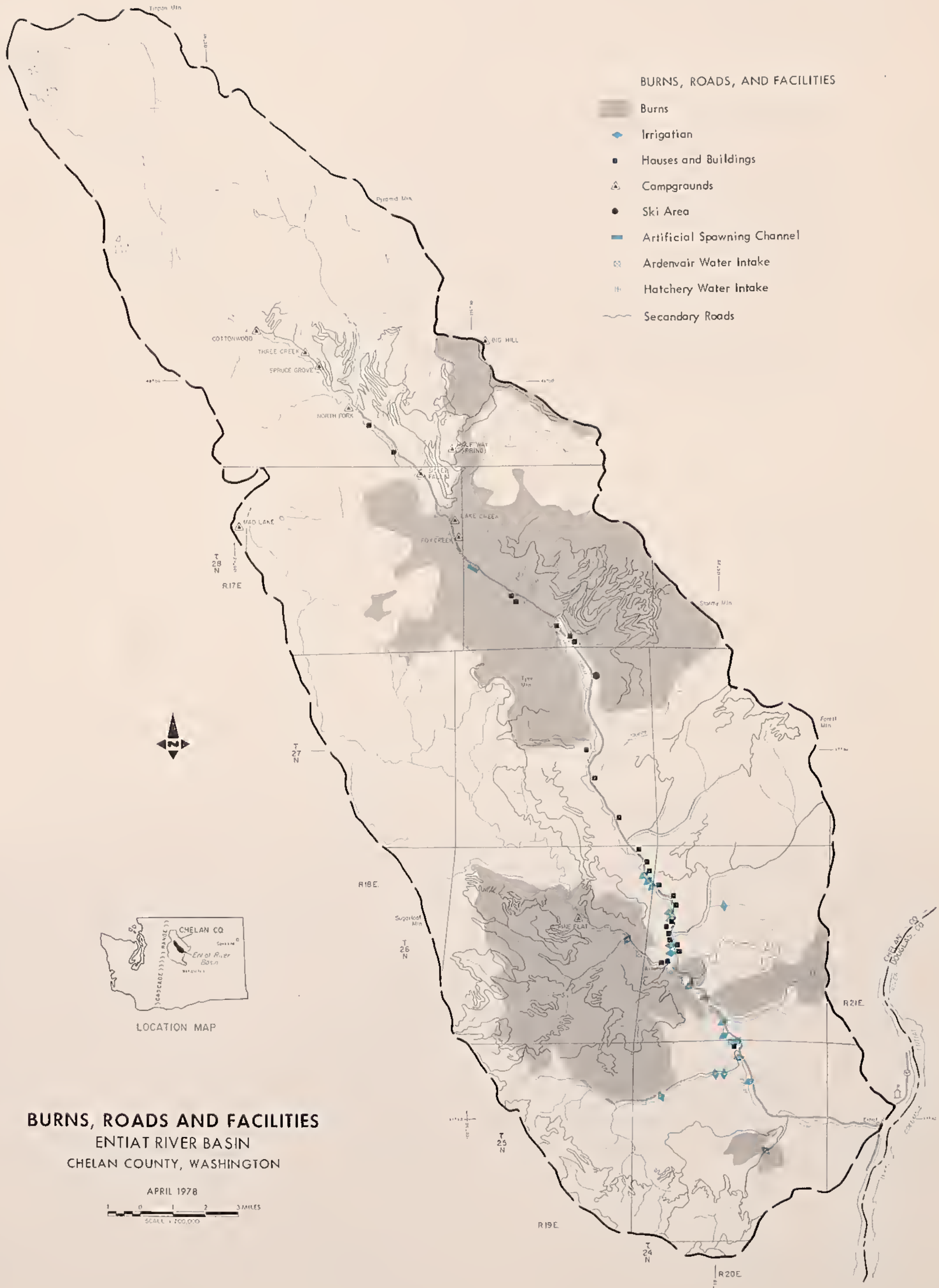
> "The water quality of the Entiat River is generally good. The dissolved solids content averages less than 60 mg/l. The maximum observed was 79 mg/l for one sample. Dissolved oxygen concentrations are normally near saturation. Occasional dips may occur seasonally, but do not constitute any significant impairment in water quality. The mean for dissolved oxygen was 11.8 mg/l with a minimum of 8.9 mg/l and a maximum of 14.2 mg/l. Coliform organisms at the sample point averaged 775/100 ml with a minimum of 0 and a maximum of 11,000/100 ml. All samples were taken at a point near the town of Entiat."

This statement does not reflect higher sediment loads which now exist.

The National Fish Hatchery obtains 93 percent of its water from the Entiat River. Wells are used for winter temperature maintenance in raceways. Spring water is used in incubation batteries because the water temperature is warmer and constant.

Water use for irrigation is discussed in other sections. The Washington State Department of Ecology has issued permits for irrigation diversion at 21 points. Fifteen of these are on the Entiat River. The others are on tributaries (see Burns, Roads and Facilities Map). Diversions from Roaring Creek suffered from low water conditions during the 1977 drought. One diversion point, and perhaps others, were changed because of this and there may be points for which records were not found.

The total number of domestic water systems obtaining drinking water directly from streams is not known. Mud Creek supplies water for the Forest Service Work Center Complex at Steliko. Chlorination is used. Other streams probably used are Roaring and Johnson Creeks and the Entiat River. The Mad River system supplying Ardenvoir is discussed in the Problem Effects Section.



BURNS, ROADS AND FACILITIES

ENTIAT RIVER BASIN

CHELAN COUNTY, WASHINGTON

APRIL 1978

SCALE 1:200,000

U.S.D.A. Eastern Washington Cooperative River Basin Study
Source:
Base map prepared by SCS, WTSC Carto Staff from U.S. Forest Service compilation.
Thematic detail compiled by U.S. Forest Service.
U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE

M7-SN-23916-5

Fish and Wildlife

Fishery — The best anadromous fish spawning area in the Entiat occurs from the vicinity of Fox Creek (river mile 27.7) downstream to the vicinity of Stormy Creek (river mile 18.4), a distance of 9.3 river miles. The present spring chinook spawning index section encompasses the upper 6 miles of this area, the section most heavily utilized by fish. The spawning gravel in the river downstream from Fox Creek was severely silted during the flood in the spring of 1972. The tributary streams, Fox, Burns, McCree, Brennegan, and Preston Creeks deposited large amounts of debris in the Entiat River eliminating much of what was once prime spawning ground.(9)

Mud Creek once supported eastern brook trout, but few fish are now to be found. Tillicum Creek has a trout fishery resulting from stocking, and the Mad River has both native and stocked trout and a few spawning anadromous fish. Both cutthroat and rainbow trout are native to the stream, and it has been well known for its Dolly Varden which occur downstream from Cougar Creek. Despite its turbulent nature, it was considered to be the principal steelhead trout producer in the Entiat system.(6)

Wildlife — A variety of birds and animals inhabit the Basin, reflecting its diverse habitat types. Chukar and various hawks are found in the arid grasslands and fields. Riparian and forest wildlife is typical of the eastern Cascade Slope. Larger animals include the badger, coyote, black bear, and probably cougar. The mule deer is of most significance to this Study, because of its shared use of rangeland and because it attracts many people to the Basin. The Entiat has long been well known to hunters. The migrant deer population grew significantly following the increased food supply provided on the revegetated burn. The deer descend through the valley to low elevation, snow-free wintering range. A herd of about 5,000-7,000 winter on the low elevation, south-facing slopes of the Potato Creek Allotment. Critical range exists in Oklahoma Gulch, Johnson Creek, the Entiat Breaks, and Morical Canyon.

In 1967, the Washington State Department of Game, Washington State Department of Natural Resources, Bureau of Land Management, Entiat Valley Stockmen's Association, and the Forest Service signed a Memorandum of Understanding providing for management of the Entiat Game Range (now called Entiat Wildlife Recreation Area) within the Potato Creek C&H Allotment. Under the terms of this agreement, protection and maintenance of wildlife habitat receives first priority consideration.

Land

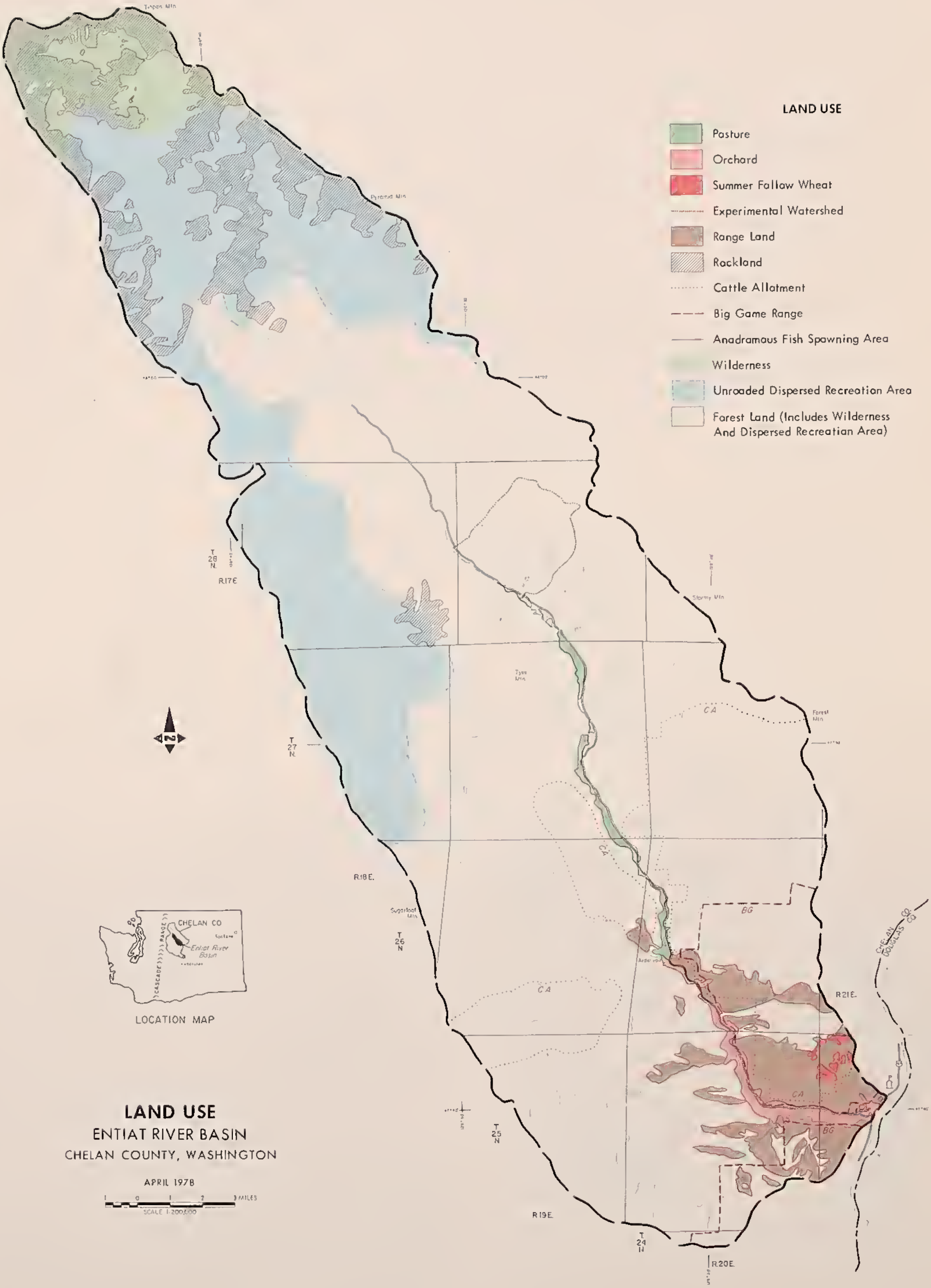
Forest land, cropland, and rangelands are discussed as well as their use. Table 5 shows the approximate distribution of this resource by use and ownership. Land use and vegetation is shown on the Land Use Map.

Table 5.—Ownership and Land Use, Entiat Basin, 1978

	Irrigated Orchard	Irrigated Hay & Pasture	Range	S.F. Wheat —Acres—	Non-Irrigated Pasture	Forest	Other[1]	Total
National Forest						200,000	20,050	220,650
Private[2]	1,300	300	7,500	300	700	22,000	2,785	34,885
DNR			700			7,380		8,080
BLM			500			2,060		2,560
Washington State Dept. of Game			320					320
USF & WS Hatchery							5	5
Total (acres)	1,300	300	9,000	300	700	232,000	22,900	266,500

[1] Other includes water (approximately 500 acres), rock and snow, urban areas and roads.

[2] Private land also includes incidental public lands.



LAND USE
ENTIAT RIVER BASIN
CHELAN COUNTY, WASHINGTON

USDA Eastern Washington Cooperative River Basin Study.
Source:
Base map prepared by SCS, WTSC Carto Staff from U.S. Forest Service compilation.
Thematic detail compiled by U.S. Forest Service.

U S DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE

M7-SN-23916-1

Forest land — Approximately 87 percent of the Basin, 232,000 acres, is forest land. The character and composition of the forest varies from a semiarid, pine-grass association, near the Columbia River, to subalpine forest and meadow at the Entiat headwaters. This variation reflects the nearly 4,000-foot range in elevation and 50-inch mean annual precipitation differential that exists within the forested part of the 42-mile long watershed.

In a zone having an average annual precipitation range of 12 to 25 inches (see Precipitation Map) widely spaced ponderosa pine begin to appear on the arid grasslands rising from the Columbia River. This is a relatively small area and soon gives way to a broader Semiarid Transitional Zone[2] which dominates the southeastern half of the Basin. At its lower end, tree cover is thin and the canopy open. As precipitation increases, the forest gradually becomes more dense until ground cover becomes an understory of bitterbrush, sagebrush, wheatgrass, cheatgrass, and associated species. North-facing slopes are more densely covered. Douglas-fir as well as ponderosa pine are common toward the upper portion of this zone. These principal species are found with varying amounts of lodgepole pine, grand fir, and western larch. Ground cover becomes heavier and includes serviceberry, dogbane, ceanothus, bitterbrush, spirea, ocean spray, pinegrass, Idaho fescue, yarrow, elk sedge, and cheatgrass.

In the Canadian Zone, the average annual precipitation ranges from 50 to 70 inches. The overstory type changes to Pacific silver fir, subalpine fir, lodgepole pine, western hemlock, and Douglas-fir. In some areas, there is Engelmann spruce, western white pine, westernlarch, and mountain hemlock. Huckleberry, kinnikinnick, false analea, dwarf salal, heather, prince's pine, and lupine for the ground cover.

The Valley's headwaters lie in the Hudsonian Zone. Average annual precipitation is 70 inches. The forest again reflects tough growing conditions at a climatic extreme. Wind and heavy snow shape scattered clumps of white bark pine, mountain hemlock, and subalpine fir, which are interspersed with meadows of lupine, phlox, various grasses, and sedges.

The destruction by the 1970 fires was so extensive, approximately one-quarter of the watershed's vegetative cover was destroyed, that the normal transition of vegetative type and species described above is obscured (see Burn Boundary on Land Use Map). On these acres a new vegetative succession and pattern was established by natural and artificial revegetation.

A description of the vegetative change typical of much of the 1970 burned area (which is forest land) is described by Tiedemann and Klock for the Entiat Experimental Forest.[10] Certain burned watersheds were seeded with a mixture of grasses. By the end of the first growing season, 1971, seeded watersheds being studied had an average of 8.6 percent ground cover. By the end of their 4-year Study, ground cover on these watersheds increased to an average of 31.2 percent. Orchard grass, a seeded species, developed rapidly. However, native species, particularly snowbrush ceanothus from seed triggered by fire, gained and retained dominance during the Study.

Approximately 80 percent of this burned area has been reforested. Reforestation of an additional 5,000 ± acres of principal forest, throughout the Basin, is already programmed for completion by 1984 (see Critical Erosion and Rehabilitation Needs Map). An evaluation by the Forest Service's Fire Rehabilitation Team, conducted in 1977, stated that "Revegetation efforts have met with good success. Both natural and seeded species are abundant. Cover is excellent . . ." Of course, vegetative conditions vary within the Burn reflecting widely varying conditions of slope, aspect, elevation, soil, treatment, and prior vegetative type. The Shady Pass area in the Silver Creek headwaters, for instance, has far less ground cover, on the average, than do other areas within the 1970 burn.

Approximately two-thirds of the 1970 burn area has been roaded. Most of these roads were in place prior to the burn and were used to facilitate salvage operations. Much of the salvage was over snow and new roads were held to a minimum. The landscapes of Brennegan and Preston Drainages, and to a lesser extent, McCree and the Gold Ridge burn area have a high density concentric system of unsurfaced, poorly maintained roads. Most of the 300 miles of road in this category are in these areas (see Land Use Map and Entiat Watershed Road Inventory, Appendix K).

A generalization of forest land use is depicted on the Land Use Map. Forest land has been shown in three categories which reflect the land allocation proposal for the Wenatchee National Forest's Chelan Planning Unit as presented in the Final Environmental Statement.

Glacier Peak Wilderness occupies approximately 12,650 acres in the Basin's headwaters. An additional 66,000 acres are not roaded and provide an opportunity for dispersed recreation activities. The remaining forest lands are managed to optimize the production of a variety of forest resources including timber, grazing, water, wildlife habitat, and recreation.

Recreation use of forest land occurs primarily on the National Forest. A variety of activities are pursued including camping, hunting, fishing, and hiking. There are 10 small campgrounds, two viewpoints, and two recreation home sites. A small winter sports site on private land and numerous roads and trails provide a base for activities dispersed throughout the forest. According to Forest Service data, total recreation use during 1976 was approximately 120,000 Visitor Use Days (As used in Forest Service recreation use tabulations, one Visitor Use Day is equivalent to 1 person staying 12 hours, 2 persons staying 6 hours, etc.). Nearly one-quarter of this use was spent in campgrounds, 22 percent on trails, and 10 percent along the forest streams. Most use, about 65 percent, was spent in dispersed activities including wilderness visits.

Approximately 22,000 acres of forest land are grazed. Included in these lands are two allotments administered by the Forest Service. The allotment boundaries (see Land Use Map) include other ownerships as well.

The Mosquito Ridge Sheep Allotment can provide approximately 1,500 Animal-Unit-Months (AUM = 1 cow-calf unit for 1 month) of grazing on the N-NE aspects in upper Kloochman Creek, Mosquito Ridge, and Tillicum Creek. This allotment, proposed for 1975, was designed to take advantage of grass, forb, and shrub regrowth following the 1970 Gold Ridge Fire.

The Potato Creek Cattle Allotment has run continuously since 1926. Approximately 80 percent of the allotment is forest land. Although use has varied, the allotment can probably support 880 AUM's. This would allow 195 cow-calf units for 4½ months. Recently, less than 130 units have been permitted. Since the 1967 cooperative wildlife agreement, cattle belonging to permittees of the Stockmen's Association are allowed to graze certain lands other than that owned by the Forest Service. The result has been that during a 4½ month season, the Association has been permitted 108 AUM's on lands owned or leased by the Department of Game and 72 AUM's on lands administered by the Bureau of Land Management.[5]

The timber resource base within the Basin was altered tremendously by the 1970 fires. This is discussed in the Economics Section.

The allowable harvest for National Forest lands for 1975 was 20.7 million board feet (MMBF). Approximately 20.3 MMBF were sold.

Two factors are of significance with respect to erosion and sedimentation and also from an economic standpoint. One is that private forest lands are being cut at an increased rate as a result of the reduced production from Federal lands. The second is that the Forest Service is now developing a new 10-year timber management plan. While the annual sustainable harvest is not yet published, the plan will reflect the change in the character of the timber base as a result of the 1970 burn. Also, it is expected that there will be a change in the harvest pattern. Emphasis will be on a variety of intermediate harvest cuts designed to enhance residual stands and utilize suppressed, dead, and dying trees. This type of harvest will minimize destruction of ground cover and soil disturbance.

Cropland — The production of apples and pears is the major agricultural enterprise in the Entiat River Basin. Of the Basin's 2,435 acres of cropland, 1,600 acres are irrigated. More than three-fourths of the irrigated land is used for orchard crops — about 813 acres apples and 458 acres pears.

Orchardlands are along the lower Entiat River and cover a relatively narrow band, less than ½ mile wide, on both sides of the stream. The orchards extend from the mouth of the River upstream about 10 miles, to the town of Ardenvoir. Here, where the elevation exceeds 1,300 feet, winters are generally too severe and late frosts are often too hazardous for the successful production of orchard crops.

Most of the bottom-land areas in the upper river valley above Ardenvoir are used for irrigated pasture. There are 329 acres of irrigated pasture in the Basin.

Production of nonirrigated crops is very limited. Only 300 acres are used for winter wheat production. This land is located on upland areas above Entiat. Annual precipitation averages 10 to 12 inches in this area, so wheat production is limited to a crop every other year. The land is summer-fallowed for moisture conservation on alternate years.

There are also 744 acres of nonirrigated pasture in the Basin. Much of this land is located along the River in small areas that are not economically feasible to irrigate. The remainder is on upland areas which are not within reach of irrigation water.

Table 6.—Average Annual Production of Entiat River Basin Cropland, 1978

Crop	Acres	Unit	Annual Production
Apples	813	Boxes	506,700
Pears	458	Tons	5,816
Wheat	150	Bushels	4,500
Irrigated Pasture	329	AUM's	2,961
Nonirrig. Pasture	744	AUM's	930

Orchards in the Basin are slightly less productive than the average for Chelan County. Productivity is reduced because of climatic conditions. Problems with irrigation distribution systems and sediments in irrigation water also reduce overall production.

For orchard crops, soils need an annual application of nitrogen. Usually, zinc and boron are sprayed on the foliage of apple trees every other year. Lime is needed on some soils that have a pH of less than 5.0, and ammonium sulphate or ferreous ammonium sulphate should be added if the pH is more than 7.5. All orchards have planted or natural grass cover crops, which are mowed to keep the grass in good condition.

Almost all orchards and irrigated pastures are irrigated with sprinkler irrigation systems. Numerous small groups of farmers in the valley have joined together into formal or informal irrigation districts or groups for the development of irrigation distribution systems. Most systems divert water from the Entiat River into small canals which carry water on the upper side of farms. Water for individual farms is then pumped from these canals with electric irrigation pump systems. Approximately 117 acres of orchard, at the Valley's mouth, are included in an irrigation district which takes water from the Columbia River. Most farmers use hand-moved irrigation pipes in orchards and on irrigated pastures.

Nitrogen fertilizer is needed for wheat grown on nonirrigated cropland. The soils are tilled so that they retain as much moisture as possible. They are seeded in late summer or early fall. Deep-furrow drills are used for seeding. Straw mulch is managed to keep the straw on the surface by fall chiseling, spring sweeping, and skew treading. Rod weeders are used to kill weeds, particularly cheatgrass, on summer fallow ground, but weedings are kept to a minimum.

Apples grown in the River Basin are mostly Red Delicious. The trees are mainly of the semidwarf variety, planted at spacing of 10 feet by 20 feet. Some newer orchards are planted at 9 feet by 18 feet spacing for increased density and higher crop yields. Most of the fruit grown in the Basin is marketed at Entiat. Some of the larger growers in the Basin have their own storage and marketing facilities.

Rangeland — There are 9,000 acres of rangeland in the Entiat River Basin. Much of the forested area is also used for livestock grazing. The rangeland areas in the Basin provide an estimated 3,517 animal unit months of grazing.

Rangeland areas are mostly steep to very steep. The soils lose water by evaporation and runoff, thus reducing the amount of moisture available for plant growth. Average annual precipitation ranges from 8 to 16 inches. Precipitation falls mostly during the winter season. The summers are hot and dry. The earliest spring plants start to grow on steep south facing slopes. These plants also mature first. The native plant community is composed of bluebunch wheatgrass, Sandburg bluegrass, Thurber needlegrass, needle-and-thread, fleabane, biscuitroot, yarrow, balsamroot, lupine, carrotleaf, buckwheat, penstemon, phlox, hawksbeard, milkvetch, rabbitbrush, sagebrush, and bitterbrush. If the range is continually abused or overgrazed, native plants are replaced by cheatgrass, brome, fiddleneck, mustard, thistle, and other weedy plants.

Average annual production on excellent condition range is 400-700 lbs./acre air dry weight, depending on yearly precipitation. About 70 percent of the plants furnish forage for livestock.

The rangeland is subject to sheet and rill erosion when vegetation and litter are sparse. It is best suited to grazing in spring and fall months. It is used as winter range by deer.

Reseeding and brush management are feasible on gentle slopes where proper seedbeds can be prepared, and when range condition is too poor to permit satisfactory improvements from grazing management alone. These practices should be closely evaluated before being applied because of potential impacts they may have on wildlife populations and habitat.

Economic and Social Resources of the Entiat Basin

Historical data of economic development and social resources of the Entiat portion of Chelan County are not available. During 1970, however, a detailed profile was tabulated by the Department of Labor of the Entiat Basin.[11]

Population and Population Characteristics

The total population in the Basin during 1970 was 1,392 persons, of which 360 lived in the town of Entiat. Basin population comprised 3.4 percent of Chelan County population.

During the calendar year 1969, one-half of the families in the Basin received income less than $8,426 per year. Approximately 10 percent of the families received less than the poverty level, while 6.3 percent received more than $15,000 (Tables 7 and 8). In 1969, one-half of the unrelated individuals received less than $4,000; 17 percent were below the poverty level, while none had incomes over $25,000.

Table 7.—Income of families and unrelated individuals 14 years old and over, Entiat Basin, 1969.

Income Range	Number of Families
Less than $2,000[1]	26
$ 2,000 to $ 2,999	23
$ 3,000 to $ 3,999	11
$ 4,000 to $ 4,999	35
$ 5,000 to $ 5,999	27
$ 6,000 to $ 6,999	31
$ 7,000 to $ 7,999	22
$ 8,000 to $ 8,999	34
$ 9,000 to $ 9,999	44
$10,000 to $14,999	102
$15,000 to $24,999	24
$25,000 and over	0
Total	379

[1]Includes no income and losses.[12]

Table 8.—Ratio of family income to poverty level[1] for families, Entiat Basin, 1969.

Ratio	Percent of all Families
Less than 0.50	4.0
.50 to .74	2.9
.75 to .99	3.4
1.00 to 1.24	4.5
1.25 to 1.49	9.0
1.50 to 1.99	16.1
2.00 to 2.99	28.5
3.00 or more	31.7

[1]Poverty levels refer to the Social Security Administration's poverty index. All tabulation concerning the poverty level include inmates of institutions, members of the armed forces living in barracks, college students living in dormitories, and unrelated individuals under age 14.[12]

Employment

The civilian labor force in the Entiat Basin was comprised of 540 persons in 1970. The total labor force participation rate was 56 percent. Civilian employment in the Basin totaled 508 persons (Table 9). The largest number of jobs occurred in the following four major industry divisions: Manufacturing, 168 persons; agriculture, forestry, and fisheries, 137 persons; retail trade, 52 persons; and wholesale trade, 42 persons. These four categories comprised 78.5 percent of total civilian employment.

Table 9.—Employed persons 16 years and older by industry, Entiat Basin, 1970.[12]

Industry	Number Employed
Agriculture, forestry and fisheries	137
Mining	6
Construction	13
Manufacturing:	
Durable Goods	155
Nondurable Goods	13
Transportation	7
Communications and Public Utilities	11
Wholesale Trade	42
Retail Trade	52
Finance, Insurance, and Real Estate	0
Services:	
Business and Repair	5
Personal	0
Medical and Health	4
Educational	21
Other Professional and Related	10
Public Administration	32
Total	508

Federal, State, and local governments employed 94 persons in nonagricultural jobs — approximately 18 percent of the total number of persons employed in the Basin.

The occupational groups were:

Group	Percent
White Collar Workers	23.0
Blue Collar Workers	46.5
Service Workers	5.1
Farm Workers	25.4
	100.0

Total employment in occupations including farm and nonfarm laborers and foremen, cleaning and food service workers, and private household workers was 32.5 percent.

Unemployment totaled 5.9 percent of the civilian labor force. Persons over 16 years old not in the armed forces, not at work, and not looking for work totaled 422. Of these persons, 30.3 percent were enrolled in school.

The average incomes by occupation groups are shown in Table 10. Farmers and farm managers had the highest average income followed by professional, managerial, and kindred workers.

Table 10.—Average income by major occupational group for persons 16 years old and older, Entiat Basin, 1969.

Occupational Group	Average
	Dollars
Male:	
Professional, Managerial, and Kindred Workers	8,154
Craftsmen, Foremen, and Kindred Workers	8,009
Operatives, Including Transport	5,934
Laborers, Except Farm	6,395
Farmers and Farm Managers	8,817
Farm Laborers Except Unpaid and Farm Foremen	3,628
Female:	
Clerical and Kindred Workers	4,194
Operatives, Including Transport	929

The variation in average incomes between males and females is the result of total weeks worked during 1969. For all females 16 years of age and over, 27 percent worked 13 weeks or less. The following breakdown shows the weeks worked in 1969.

Weeks Worked		Males	Females
50-52		287	50
40-49		46	24
27-39		36	19
14-26		28	66
13 or less		63	127
Did not Work In 1969		28	188
	Total	488	474

Approximately 59 percent of the male labor force worked 50-52 weeks in 1969.

A detailed list of employment by occupation for the Entiat Basin is shown in Table 11. Farm workers comprised the largest occupational group with 25.4 percent of the employed persons.

Table 11.—Employed persons 16 years and over by occupation, Entiat Basin, 1970.

Occupation	Percent	
Professional, Technical, and Related		6.3
Engineers	1.2	
Medical and Health Workers	0.0	
Teachers, Elementary Plus Secondary	1.2	
Other Professional Workers	3.9	
Nonfarm Managers and Administrators		7.3
Salaried	6.1	
Self-Employed	1.2	
Sales Workers		2.8
Retail Stores	1.8	
Other Sales Workers	1.0	
Clerical Workers		6.7
Craftsmen, Foremen, and Related		11.4
Construction Craftsmen	3.3	
Mechanics and Repairmen	1.0	
Machinist and Other Metal	1.0	
Other Craftsmen	6.1	
Operatives, Except Transport		18.3
Durable Goods Manufacturing	10.4	
Nonmanufacturing	7.9	
Transport Equipment Operatives		7.3
Nonfarm Laborers		9.4
Service Workers, Except Private Household		5.1
Cleaning and Food Service Workers	3.1	
Personal, Health, and Other	2.0	
Farm Workers[1]		25.4
Total		100.0

[1]Includes farmers, farm managers, farm laborers, and foremen.

Production

Historical and present situation data for the Entiat portion of Chelan County were not available at the beginning of this Study. Cooperating agencies of the U.S. Department of Agriculture conducted an analysis of land use and productivity by Soil Resource Groups (SRG). The land resource was classified into relatively homogeneous soil groups based on soil associations and soil management areas.

Soil resource groups are homogeneous with respect to slope, texture, permeability of the substrata, suitability for similar types of crops, selected input requirements, management, and yield.

The Economics, Statistics, and Cooperatives Service developed forms that were used by Forest Service and Soil Conservation Service personnel in estimating crop acreages, fertilizer application, yield, and water use for each basic SRG observation.

The Soil Resource Groups, which include agricultural lands, comprise 13.6 percent of the Basin. The remainder of the Basin is managed under forestry programs.

Irrigated cropland comprised 1,300 acres, or 93 percent of total cropland (Table 12). All of the irrigated cropland was utilized in the production of apples and pears. Irrigated pasture comprised an additional 300 acres, resulting in a total irrigated area of 1,600 acres.

Table 12.—Total private land in inventory by Soil Resource Group and land use, Entiat Basin, 1976.

Land Use	Soil Resource Group								Total
	1	3	4	5	6	7	8	9	
	Acres								
Total cropland	129	0	937	190	366	1	0	7	1,565
Total irrigated cropland	129	0	937	20	171	1	0	7	1,265
Apples	83	0	600	13	109	1	0	4	810
Pears	46	0	337	7	62	0	0	3	455
Total nonirrigated cropland	0	0	0	170	130	0	0	0	300
Wheat	0	0	0	85	65	0	0	0	150
Summer fallow	0	0	0	85	65	0	0	0	150
Pasture-range, total	233	109	1,044	782	790	6,649	317	128	10,052
Pasture, total	8	109	57	240	598	50	0	11	1,073
Improved pasture, nonirrigated	0	0	0	0	0	0	0	0	0
Improvable pasture, nonirrigated	4	76	37	168	419	35	0	5	744
Improvable pasture, irrigated	4	33	20	72	179	15	0	6	329
Range, total	225	0	987	542	192	6,599	317	117	8,979
Forest grazed	0	1,041	0	4,007	13,298	3,598	0	0	21,944
Other land, total	16	330	202	557	228	0	46	0	1,725
Total land in inventory	378	1,480	2,183	5,536	14,682	10,248	363	135	34,940

Table 13.—Agricultural production by Soil Resource Group Entiat Basin, 1976.

Commodity	Units	Soil Resource Group 1	3	4	5	6	7	8	9	Total
Apples	Boxes	58,100	0	360,000	10,400	76,300	500	0	1,400	506,700
Pears	Tons	644	0	4,044	112	992	0	0	24	5,816
Wheat	Bu	0	0	0	2,550	1,950	0	0	0	4,500
Improvable pasture, nonirrigated[1]	AUM	6	114	55	252	628	26	0	7	1,088
Improvable pasture, irritaged[1]	AUM	40	330	200	720	1,790	150	0	30	3,260
Range[1]	AUM	90	1,041	694	325	384	4,198	32	12	6,776
Commercial forest grazed	AUM	0	0	0	5,008	11,968	0	0	0	16,976

[1]High level management yields.[13]

Agriculture crop production in the Entiat Basin is shown in Table 13. Soil Resource Groups 4, 5 and 6 accounted for approximately 88 percent of the apple and pear production. Seventy-one percent of the wheat was produced in SRG 6 during 1976.

Yields from pasture, range, and commercial forest lands grazed amounted to 28,100 animal unit months (AUM) during 1976.

The Basin has one sawmill, at Ardenvoir, which utilizes most of the Basin's timber production. The mill also relies on logs from outside the Basin, especially since 1972, in order to maintain its annual production of approximately 30 million board feet.

The mill, owned by Pack River, employs about 105 people and usually operates two shifts producing about 130 thousand board feet (MBF) per day [4]. A breakdown of log source is not published. However, the National Forest contains approximately 82 percent of the Basin's available timber producing lands, private lands approximately 13 percent, with State and Bureau of Land Management providing the remaining 5 percent. Prior to 1970, the mill probably obtained about 75 percent of its logs from National Forests. Since the fires and the sale of salvage timber in 1971, National Forest timber sales have dropped significantly to probably less than half-mill production.

Table 14 is a tabulation of the National Forest timber actually sold since 1962. As stated previously, cutting patterns have changed to other timber sources since 1972. The Wenatchee National Forest and Entiat Ranger District are currently revising allowable harvest volumes.

Table 14.—Allowable Harvest and Volume of Timber Sold Entiat Ranger District

	Allowable Cut	Sold	
	MMBF		MMBF
1963 - 1970 (6/30/70)	22.6	1962	19.9
		1963	32.3
		1964	20.0
		1965	16.6
		1966	29.8
		1967	13.8
		1968	20.6
		1969	18.9
7/1/70 - 1973	16.8	1970	24.6
		1971	36.1[1]
		1972	11.5
		1973	1.2
1974 to present	20.7[2]	1974	1.0
		1975	20.3
		1976	1.3
		1977	14.2

[1]The volume sold in 1971 consisted of fire salvage sales.

[2]The fluctuation in allowable cut reflects a redistribution within the working circle for which the Timber Management Plan was prepared.

Chapter 2—Projections and Assumptions
(The Without Plan)

The purpose of this section is to present a set of projections of what might happen under a given set of assumptions. It is especially important to project what would happen with a continuation of current programs and investments. This is an alternative for dealing with the Basin's problems which must be considered and should be used in assessing the costs and benefits of various remedial proposals.

The economy of the Entiat is expected to continue to be based on forest products, orchard produce, recreation, and livestock. Orchards have expanded to near their climatic limit and little further expansion is expected. Agricultural soils suitable to hay, pasture, and other crops have been developed. The acreage of this land is expected to decline slightly as it is occupied by homes and recreation residences.

This residence expansion will be limited by the relatively small amount of developable acreage in private ownership. Most of the level land is in the floodplain of the Entiat or on tributary alluvial fans and is subject to periodic flooding. The primary recreation attraction, hunting, is expected to continue at present levels. Management plans seek to balance the use of rangelands between livestock and wildlife. While forage has increased tremendously since the 1970 burn, the limiting factor is the relatively snow-free critical winter range which remains stable. Wilderness use and recreation use of undeveloped forest areas will increase. The slight increase in homes and recreation residences will be based, in part, on those seeking the rural environment in proximity to these amenities.

While the production of forest products has dropped significantly, the productive forest land base remains. The harvest from private forest lands is expected to remain high for at least 10 years. During this time, harvests from National Forest lands will remain low. The current Ten Year Timber Management Plan, now being formulated, will reflect the change in timber stand base. There will be a reduced sustainable harvest. Intermediate cuts rather than regeneration cuts will be emphasized.

The effect of this will be development of timber resources in the upper Watershed which minimizes soil disturbance and tends to retain ground and canopy cover. At the same time, there will be increased disturbance and devegetation of private lands which are mostly in the lower Basin and Mad River area.

Remedial work within the Basin has included the installation of streambank riprap along orchards and other areas to prevent land loss. This activity has received significant assistance through cooperative programs administered by the Agricultural Stabilization and Conservation Service. Funding is expected to remain at current levels.

Another continuing effort is the restoration of vegetation on burn areas and the stabilization of streambanks, slides, and other sediment sources.

The Entiat Ranger District expects to continue a sediment reduction and erosion control program of about $20,000 per year. Work will probably include debris removal from stream channels; hand terracing; shrub, willow, and forb plantings to stabilize banks, and similar handwork. The Young Adult Conservation Corps and similar programs will be used, as appropriate, perhaps extending dollars as well as meeting program goals.

The following is from Tiedemann and Klock[10] for various areas on the experimental forest and may be useful in predicting the progression of ground cover restoration.

Table 15.—Vegetative cover by aspect on certain watersheds—1971 through 1974.

	Fox[2]		Brennegan[3]		Burns		McCree	
	S	W	S	W	S	W	S	W
	Percent							
1971	8.7	2.2	10.8	9.8	11.6	10.0	8.8	6.3[1]
1972	26.1	6.2	18.6	14.2	26.9	19.1	18.5	21.5
1973	26.6	10.7	26.4	24.0	28.7	21.8	18.9	19.2
1974	35.9	18.2	37.4	28.6	34.4	30.1	32.3	28.0
Mean	24 3	9 3	23.3	19.1	25.4	20.2	19.6	18.8

[1]Simple average of values across an individual year does not equal average total cover because of different number of transects on each watershed and aspect.

[2]Fox was roadless with no seeding or fertilization.

[3]Brennegan was not fertilized

S = South facing slope. W = West

Approximately 5,000 acres remain to be reforested. This is programmed for completion by 1984. When this planting is successfully completed, the reforestation of commercial forest land within the 1970 burn area will be completed. An additional acreage of "marginal forest" is not planned for reforestation.

Prior to 1970, the following vegetative types were described on the experimental forest by Tiedemann and Klock. These may be indicative of the makeup of future habitat types:

> The lower, more xeric sites of 1,800 to 3,000 foot elevation consisted of an overstory of ponderosa pine with an understory of bitterbrush and serviceberry. Arrowleaf balsam root, braken fern, spreading dogbane, and bluebunch wheatgrass were prominent herbaceous species. Lower elevations are probably representative of the *Pinus ponderosa*/Purshia-/Agropyron habitat type described by Daubenmire and Daubenmire (1968)

> At intermediate and higher elevations of 3,000 to 5,500 feet Douglas-fir became more prominent, often occurring in almost pure stands on moister sites. Lodgepole pine normally occurred only in small, dense thickets. Snowbrush ceanothus, willow, and Sitka alder were common shrubs. Intermediate elevations are characteristic of the *Pseudotsuga menziesii-/Calamagrostis rubenscens* habitat type. At elevations over 5,800 feet, whitebark pine was common.(10)

A study of forested range(14) indicates that for forested range sites, vegetative ground cover fully occupies sites within 7 years. Sites left to recover naturally overtook treated sites within that time so that after 7 years, the percent of ground cover was approximately the same on treated and untreated sites. This is the existing condition of much of the Entiat Burn; i.e., a fully occupied site effecting a ground cover ranging from 30 to 40 percent.

Ground cover will probably decline in relation to tree crown cover. An estimate of crown closure for ponderosa pine(15) indicates that crown closure for a fully stocked, managed stand of ponderosa pine will be about 12 percent at age 15 after spacing (thinning) and approximately 55 percent at age 35 on average site IV land.

"Current Program" alternatives (without plan alternatives) are discussed in the alternatives Section of this Report. These address erosion reduction and sediment reduction objectives. Costs and consequences based partially on the preceding assumptions are discussed in the presentation of these alternatives.

Chapter 3—Problems and Effects

U.S. Geologic Survey stream flow gaging station on Main Entiat River. Note fine partical sediment accumulation.

Problems on the Uplands

Increased water yield, erosion, and sedimentation are the underlying causes of most of the problems affecting the Basin. The following quantification and discussion of these factors is from a *Hydrologic Analaysis for Forested Lands, Entiat River Basin.* [25] This analysis was completed as part of this U.S.D.A. River Basin Study.

Water Yield

The mean annual runoff (See Precipitation and Runoff Map) in the Entiat River Basin is directly correlated with elevation and mean annual precipitation as indicated by the attached regression. (Figure 9).

The U.S. Geological Survey surface water supply papers published for the Entiat stream gage at the mouth of the Entiat River (abandoned 1958) and on the Entiat River at Ardenvoir were the basis for estimating mean annual water yield from the Basin before and after the 1970 wildfire which consumed approximately 106 square miles in the Study area.

An analysis of the U.S. Geological Survey water yield data indicates the following significant points:

Source Location	Drainage Area mi^2	Water Year Period of Record	Mean Annual Runoff · Feet	Mean Annual Runoff · Ac. Feet
USGS Gage at mouth of Entiat	419	51-58	1.37	367,379
USFS data mouth of Entiat[1]	419	70-76	1.97	528,275

The above data indicates a 44% mean annual increase in total water yield, following the 1970 fire, from the entire Watershed — Entiat River at Entiat. The above data is only an estimate since postfire water yield was not available from the Entiat River at Entiat and correlations were used.

[1]Adjusted from USGS gage, Entiat River at Ardenvoir.

PRECIPITATION AND RUNOFF

ENTIAT RIVER BASIN

CHELAN COUNTY, WASHINGTON

APRIL 1978

SCALE 1:200,000

USDA Eastern Washington Cooperative River Basin Study.
Source:
Base map prepared by SCS, WTSC Carto Staff from U.S. Forest Service compilation.
Thematic detail compiled by U.S. Forest Service.

U S DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE

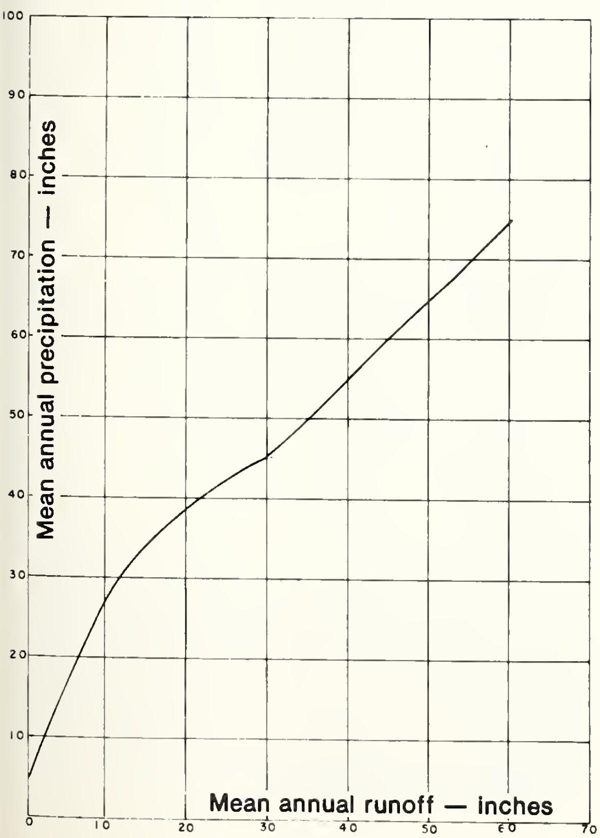
M7-SN-23

The U.S. Geological Survey gaging station at Ardenvoir has before and after fire water yield data which supports a 41 percent increase in water yield in the upper Watershed following the 1970 wildfires.

Source Location	Drainage Area mi^2	Water Year Period of Record	Mean Annual Runoff - Feet	Mean Annual Runoff - Ac. Feet
USGS Station: Entiat River at Ardenvoir	203	61-70	1.92	249,446
USGS Station: Entiat River at Ardenvoir	203	71-76	2.70	350,784

Figure 9.—Entiat River Basin Relationship Precipitation to Runoff

By C.R. Benoit 2/10/78
Data Source: USGS, SCS, USFS, USWS



The above comparative data is significant; however, since different annual precipitation occurred during each year, only the mean data for the period of record can be held above suspect even though empirical adjustments for precipitation were made.

The following results and discussion of water yield increase by J. Helvey, Hydrologist; A Tiedemann, Range Scientist; and W. Fowler, Meteorologist, Pacific Northwest Forest and Range Experiment Station, U.S. Forest Service, USDA, Wenatchee, Washington; in the experimental forest portion of the Basin supports the conclusion that a significant water yield increase has occurred following the 1970 wildfire. The water yield increase is primarily attributable to the reduction in transpiring vegetation. These research scientists also documented reduction in diurnal flow pattern, a shift to earlier peak flows, and significant increases in annual peak discharge.

Three early effects of the fire on hydrologic behavior were reported by Berndt (1971). Flow rate on McCree Creek decreased from 6.25 to 1.71 liters (0.22 to 0.06 cubic foot) per second during the 12 hours in which the fire was burning intensely. This response was attributed to "vaporization of water from live stream surfaces ventilated by strong convective currents." Another striking effect was in the diurnal pattern of flow. Before the fire, flow rates followed a regular cycle, reaching a maximum at about 0800 and a minimum at 1900 hours. After the fire, daily oscillations were virtually eliminated because vegetation along stream channels was destroyed and no longer transpiring

water. The third effect noted by Berndt was a gradual increase in flow rate to a level above the prefire values. He could not detect a change in water temperature.

Helvey (1972, 1974) reported first-year and second-year results of the fire on yield and temperature of water (Table 16). Records collected in the headwaters of the Entiat River by the U.S. Forest Service under its Barometer Watershed Program and on the Chelan River by the U.S. Geological Survey served as control data for evaluating water yield changes. Fire did not touch the headwaters of the Entiat River, and only about 10 percent of the Chelan River drainage was burned.

Table 16.—Prefire hydrologic data for the three watersheds on the Entiat Experimental Forest

Hydrologic Factor		McCree	Burns	Fox
Average Annual Yield -	centimeters	11.2	15.5	17.7
	(inches)	(4.4)	(6.1)	(6.9)
Maximum Annual Yield -	centimeters	13.5	19.1	24.9
	(inches)	(5.3)	(7.5)	(9.8)
Minimum Annual Yield -	centimeters	8.6	12.2	12.7
	(inches	(3.4)	(4.8)	(5.0)
Maximum Daily Flow Rate -	liters per second	164.4	243.7	167.2
	(cfs)	(5.8)	(8.6)	(4.8)
Minimum Daily Flow Rate -	liters per second	4.5	10.8	10.5
	(cfs)	(0.16)	(0.38)	(0.37)

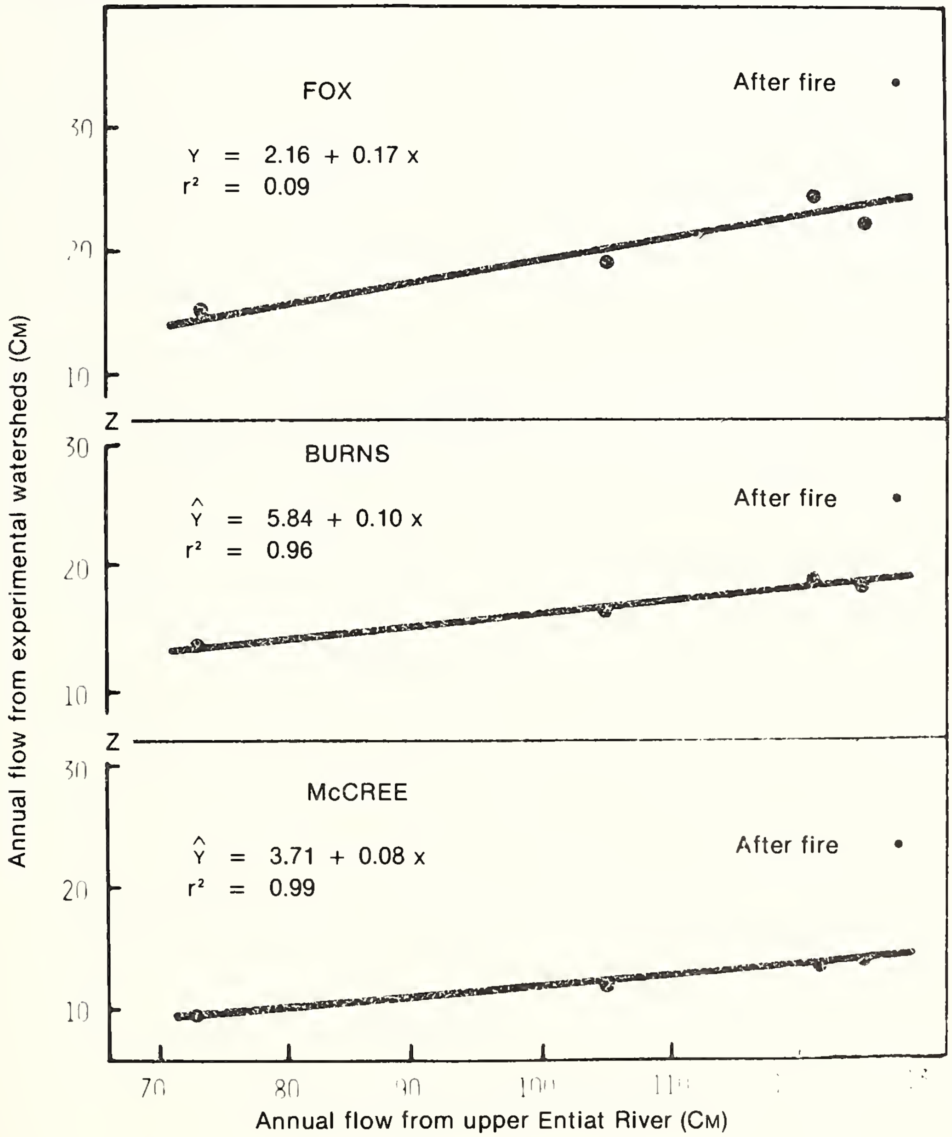
Figure 10 depicts differences between predicted and measured yield for water year 1971 — the first year after the fire. Yield increases, based on control data from the Entiat River, were 9.4 cm (3.7 in.) for McCree, 10.4 cm (4.1 in.) for Fox, and 6.9 cm (2.7 in.) for Burns Watersheds. Comparable values based on Chelan River data were 9.1, 11.2, and 7.4 cm (3.5, 4.4, and 2.9 in.) for McCree, Fox and Burns Watersheds, respectively. Measured yield from the three Watersheds totaled 1.39 x 10^6 m^3 (1,130 acre-feet). This was 50 percent more water than the predicted value based on prefire vegetation conditions. The extra water was produced during snowmelt and late summer months. Another paper by Klock and Helvey discusses soil moisture-streamflow relationships.

Water year 1972 was characterized by much greater than normal precipitation. The snowpack was one of the deepest ever recorded in most of the Cascade Range in Washington. Snow depth on the Experimental Forest was 150 percent of normal in mid-March 1972. Record high air temperature in mid-March increased flow rates, which in turn caused channel cutting. The weir pond on McCree Creek, which had not required cleaning during the 10-year calibration period, filled with sediment at 1-day or 2-day intervals. Discharge rates of 509 liters (18 cubic feet) per second were measured during the second week of March — more than three times the volume of soil, rock, and logging debris was carried into the main gaging station. When water built up a sufficient head behind the dam, it broke through and a wall of water and debris about 11 m^2 (100 ft^2) in cross-section flowed down the main channel and destroyed the gaging station.

)

Figure 10.—Annual Streamflow from the Three Experimental Watersheds

Entiat Experimental Forest, before the fire and the first year after burning in relation to annual flow from Upper Entiat River.



Intense rain showers on June 9 and 10 delivered 8.1 cm (3.2 in.) of precipitation within 30 hours. One burst of 3.8 cm (1.5 in.) was delivered in 30 minutes. Discharge rates increased rapidly, and Fox Creek weir was destroyed by a massive debris flow.

Another intense storm on August 15 delivered 6.6 cm (2.6 in.) of rain to parts of the Watershed and caused additional debris flows on McCree and Fox Creeks.

The gaging station on Burns Creek was filled with debris during the June 9 and August 15 storms, but fortunately was cleaned out to continue the discharge records.

Figure 11.—Annual Hydrographs for Burns Creek

Note that flow rate following the fire was much greater during snowmelt and late summer months.

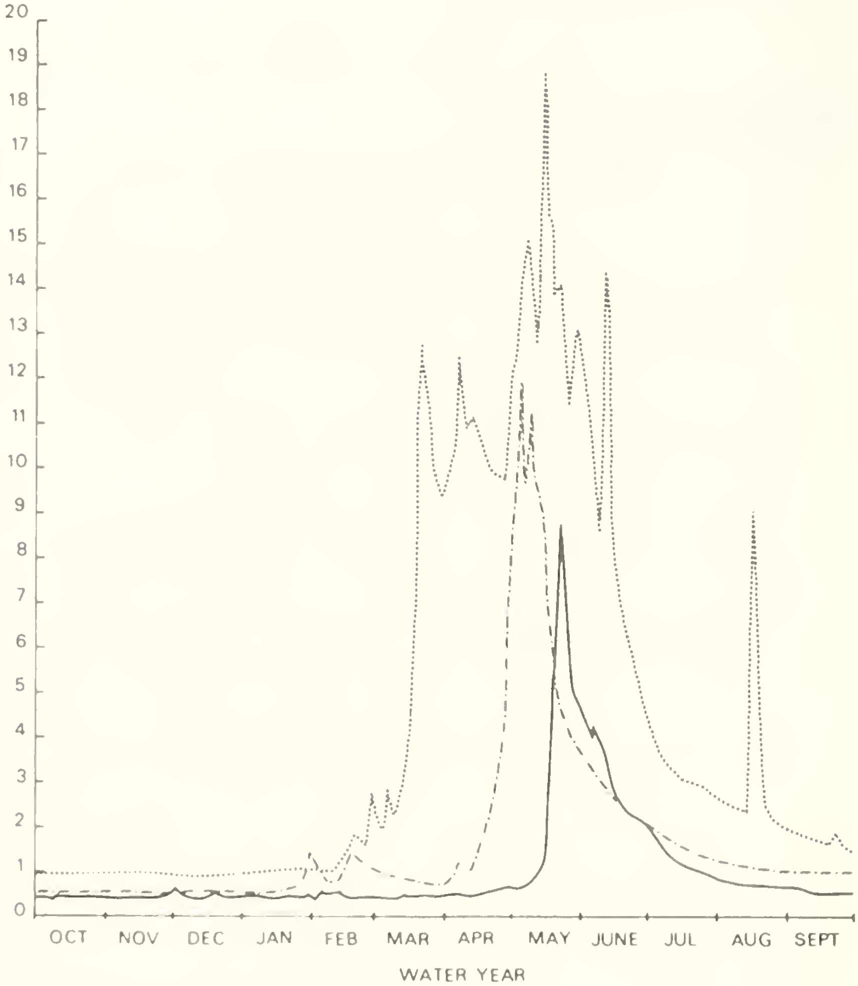


Figure 11 illustrates the hydrograph on Burns Creek for the year of maximum runoff during calibration and hydrographs during the first and second years after the fire. Compared with the calibration year of 1966-67, runoff from snowmelt started about 1 month earlier in 1970-71 and about 2 months earlier in 1971-72. Possible reasons for the earlier and greater rate of snowmelt, in addition to the obvious effects of higher than normal temperature, include a lower snow albedo caused by dust from the blackened timber and increased surface exposure caused by decreased shade after the overstory was killed. Higher soil moisture levels caused by reduced evapotranspiration loss during the previous summer probably contributed to the earlier and greater rates of runoff in 1971-72.

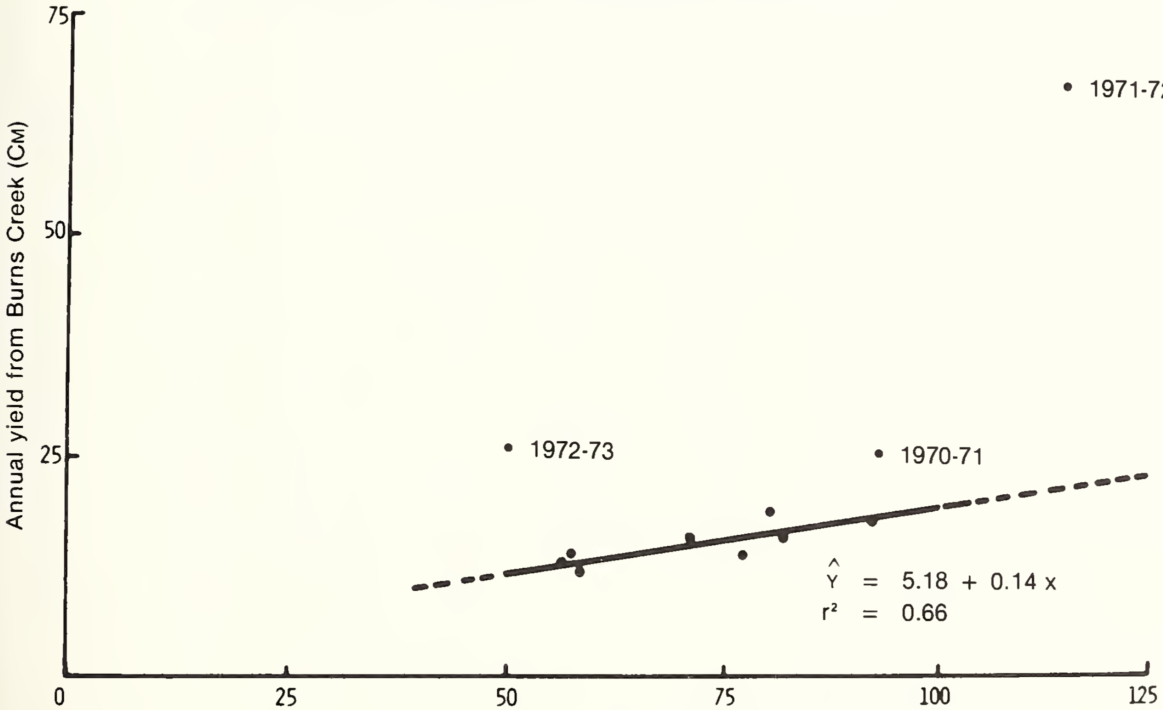
Precipitation during water year 1973 was in sharp contrast to that of the previous year. Precipitation in 1971-72 was one of the highest on record; in 1972-73, one of the lowest. Runoff was orderly with peak discharge rates not exceeding 170 liters (6 cubic feet) per second.

Because the stream-measuring stations on McCree and Fox Creeks were destroyed by debris flows, we do not have an annual runoff value for these streams for the 1971-72 water year. Annual water yield from Burns Creek is compared in Figure 12 with annual yield from the Chelan River. The prefire regression has a standard error of 1.4 cm (0.55 in.) at the 0.67 probability level. Measured yields minus predicted yields from Burns Creek were 7.4, 47.2, and 17.8 cm (2.9, 18.6, and 7.0 in.) for the first, second, and third years after the fire, respectively.

The computed yield increase for water year 1971-72 is suspect because measured flow from the Chelan River was considerably greater than during the calibration period. Therefore, the regression requirement that prediction should not be made beyond the limits of the calibration data could not be met, and extrapolation of the prefire linear relationship probably is not justified. However, experiments in other parts of the country have shown that water yield response to tree removal varies directly with current annual precipitation (Rich 1972). From evidence, we conclude that yield increase due to evapotranspiration savings was greater during water year 1972 than in 1971 but probably less than the value (47.2 cm) obtained by extending the linear calibration curve and subtracting predicted runoff from measured runoff.

Figure 12.—Annual Water Yield from Burns Creek

Before and during the first 3 years after the fire in relation to annual yield from Chelan River



Water yield in 1972-73 from Burns Creek was 26.7 cm (10.5 in.), more than double the predicted value based on prefire conditions. This value was influenced by the high precipitation during the previous year. These Watersheds apparently contain a huge soil reservoir which stores moisture and releases it gradually to streamflow. Water yield during a dry year which follows a wet year will be somewhat greater than during a similar dry year which follows a dry year. In other words, the water-yielding "dials" are not necessarily set to zero on September 30 of each year.

Channel Erosion and Sediment Yield

Table 17 is an estimate of annual sediment production from the 297 miles of perennial stream in the Basin. It was developed by correlating stream stability survey data with the relationship of stream stability to stream channel erosion (Figure 13). An overall sediment delivery ratio of 0.85 was used (See Channel Stability Discussion, Appendix).

In summary, approximately 72 percent of the fluvial sediment contribution from the forest lands in the Entiat River Basin originates in the stream channel system. If the water quality objectives in this Basin are to be accomplished, effort should be concentrated on streambank and lower slope erosion sources. Of the total sediment originating from the stream system, 68 percent originates from only 24 percent or 71 miles of stream. This constitutes the very poor, poor, and fair stability categories.

The Stream Channel Stability Map shows stability ratings for various reaches of the Basin's streams. Seven categories are depicted. For each, the total miles, erosion range, and gross erosion and sediment tons per year are shown.

This map can be used to direct remedial work to reaches contributing most to the instream sediment problem.

Table 17.—Entiat River Basin Stream Channel Stability — Erosion and Sediment

Point Score**	Map Color	Stability Rating	Total Miles	Channel Erosion Range and Median Tons/Mile/Year			Gross Erosion Tons/Yr.	Gross Sediment Tons/Yr.*
<64	Purple	Excellent	60	<1	2.5	5	150	125
65-74	Blue	V. Good	60	5	15.0	25	900	765
75-84	Green	Good	72	25	37.5	50	2,700	2,295
85-94	Yellow	V. Fair	34	50	100.0	150	3,400	2,890
95-104	Pink	Fair	35	150	175.0	200	6,125	5,206
105-114	Orange	Poor	25	200	225.0	250	5,625	4,781
>115	Red	V. Poor	11	250	300.0	>300	3,300	2,805
	TOTAL		297				22,200	18,867

*Mean Sediment Delivery Ratio = .85

Note: Dashed Lines = Intermittent Streams
Mean Channel Sediment = 63.53 tons/mile/year

**Map based on field inventory using *USFS Stream Reach Inventory and Channel Stability Evaluation System*, 1975.

ENTIAT RIVER BASIN

Stream Channel Stability-Erosion and Sediment Survey Legend

	Point Score **	Stability Rating	Total Miles	Channel Erosion Range and Median Tons/Mile/Year			Gross Erosion Tons/Year	Gross Sediment Tons/Year
	<64	Excellent	60	<1	2.5	5	150	125
	65-74	Very Good	60	5	15.0	25	900	765
	75-84	Good	72	25	37.5	50	2,700	2,295
	85-94	High Fair	34	50	100.0	150	3,400	2,890
	95-104	Fair	35	150	175.0	200	6,125	5,206
	105-114	Poor	25	200	225.0	250	5,625	4,781
	>115	Very Poor	11	250	300.0	300	3,300	2,805
		TOTAL	297				22,200	18,867

* Mean Sediment Delivery Ratio = .85

Note: Dashed Lines = Intermittent Streams

Mean Channel Sediment = 63.53 tons/mile/year

** Map based on field inventory using: USFS Stream Reach Inventory and Channel Stability Evaluation System, 1975.

STREAM CHANNEL STABILITY

ENTIAT RIVER BASIN

CHELAN COUNTY, WASHINGTON

APRIL 1978

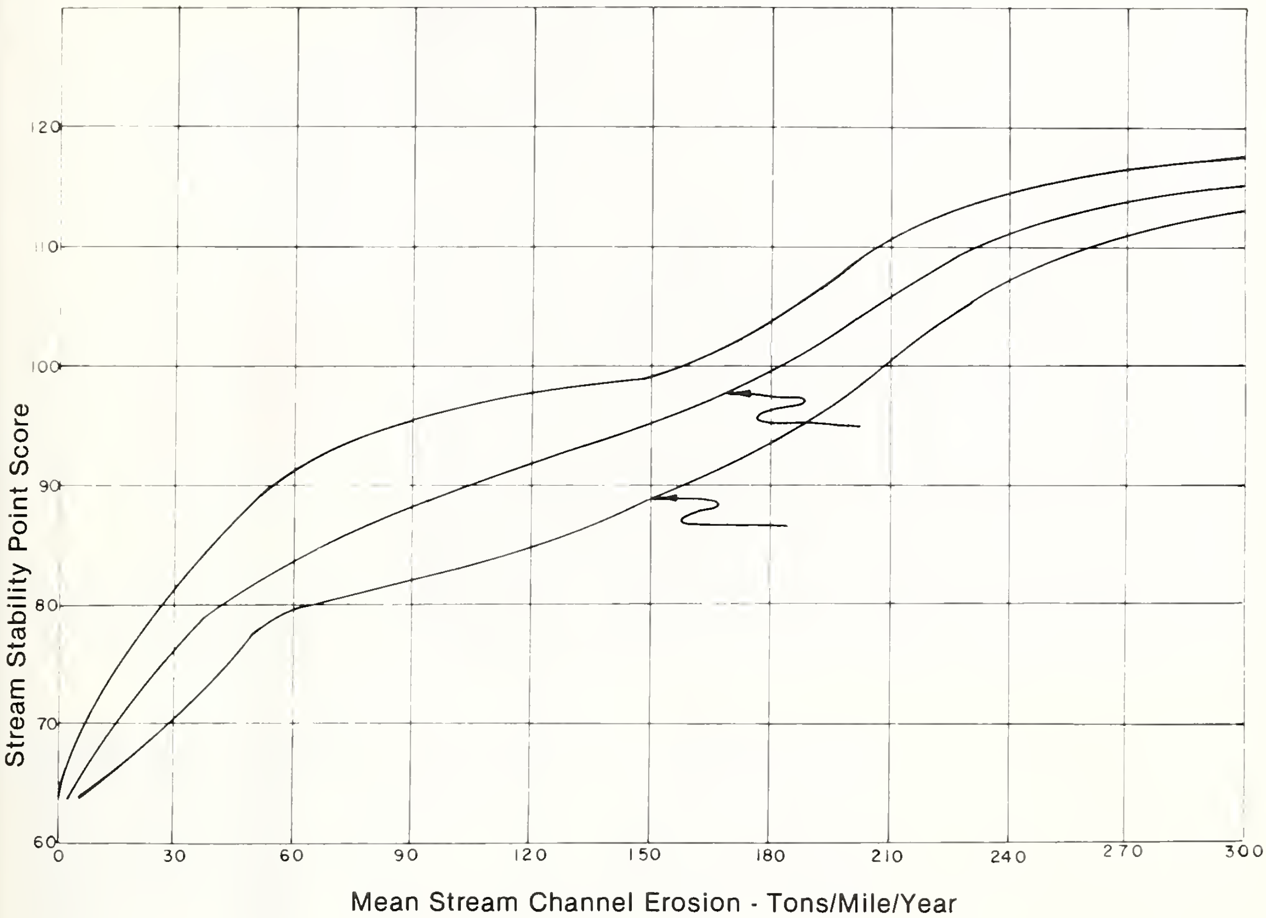
SCALE 1:200,000

Sources: Base map prepared by SCS, WTSC Carto Staff from U.S. Forest Service compilation. Thematic detail compiled by U.S. Forest Service.

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE

M7-SN-23916-8

Figure 13.—Stream Stability - Erosion Production
Quantified Relationship



$r^2 = .88$

Data Source: Field data

Entiat, Yakima, and Colville River Basins

A successful method used to help keep culvert open to safely dispose of runoff.

Here the rate of dry creep and slope are beyond the capacity of the rocked culvert headwall.

AGRICULTURAL LAND EROSION & FLUVIAL SEDIMENT DISTRIBUTION

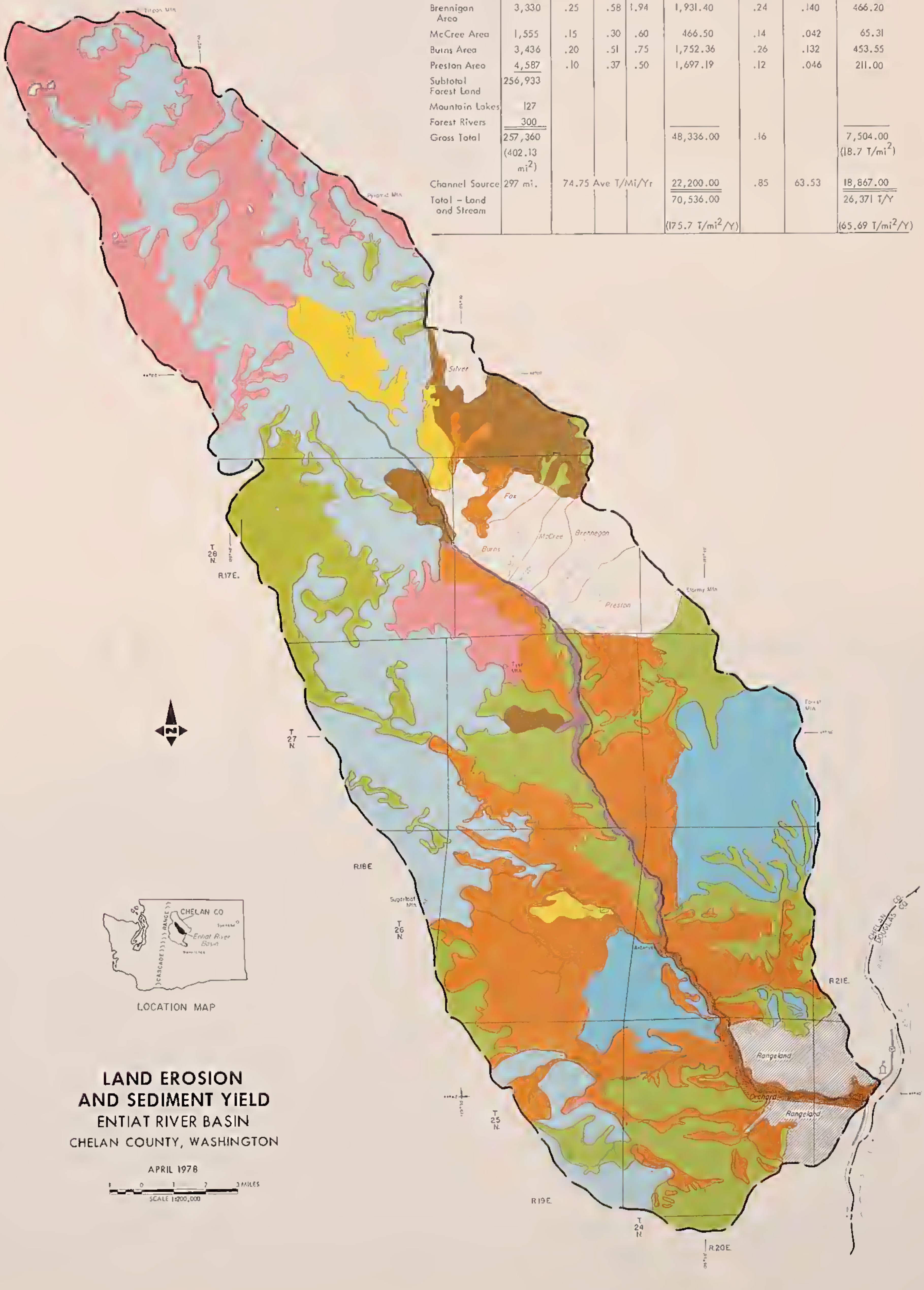
MAP UNIT	AREA IN ACRES	MEAN EROSION RATES RANGE AND MEDIAN TONS/ACRE/YEAR			MEAN GROSS EROSION TONS/YEAR	SEDIMENT DELIVERY RATIO	MEAN SEDIMENT RATE TONS/ACRE/YEAR	MEAN GROSS SEDIMENT TONS/YEAR
		L	M	H				
Rangeland	7,484	.50	.75	1.0	5,613.00	.20	.15	1,122.60
Orchard	1,583	.10	.25	.50	395.75	.12	.03	47.49
Subtotal Ag. Land	9,067							
Rivers	73							
Gross Total	9,140 (14.28 mi^2)				6,008.75	.19		1,170.09 (81.94 mi^2)

ENTIAT BASIN

FOREST LAND EROSION AND FLUVIAL SEDIMENT DISTRIBUTION

MAP UNIT	AREA ACRES	MEAN EROSION RATES RANGE AND MEDIAN TONS/ACRE/YEAR			MEAN GROSS EROSION TONS/YEAR	SED. DEL. RATIO	MEAN SED. RATE T/AC/YR	MEAN GROSS SEDIMENT TONS/YEAR
		L	M	H				
	6,304	.04	.06	.13	378.24	.13	.008	50.43
	64,270	.01	.03	.05	1,928.10	.10	.003	192.81
	9,116	.10	.14	.20	1,276.24	.16	.023	209.67
	35,571	.30	.43	.50	15,295.53	.15	.063	2,240.97
	54,249	.20	.24	.30	13,019.76	.13	.031	1,681.72
	21,061	.15	.19	.25	4,001.59	.14	.027	568.65
	48,461	.05	.10	.15	4,846.10	.16	.016	775.38
	2,509	.001	.01	.06	25.09	.10	.001	2.51
Fox Cr. Area	937	.50	.76	4.17	712.12	.35	.265	248.31
Upper Silver Area	1,547	.30	.65	2.81	1,005.55	.34	.218	337.25
Brennigan Area	3,330	.25	.58	1.94	1,931.40	.24	.140	466.20
McCree Area	1,555	.15	.30	.60	466.50	.14	.042	65.31
Burns Area	3,436	.20	.51	.75	1,752.36	.26	.132	453.55
Preston Area	4,587	.10	.37	.50	1,697.19	.12	.046	211.00
Subtotal Forest Land	256,933							
Mountain Lakes	127							
Forest Rivers	300							
Gross Total	257,360 (402.13 mi^2)				48,336.00	.16		7,504.00 (18.7 T/mi^2)
Channel Source	297 mi.	74.75 Ave T/Mi/Yr			22,200.00	.85	63.53	18,867.00
Total - Land and Stream					70,536.00 (175.7 T/mi^2/Y)			26,371 T/Y (65.69 T/mi^2/Y)

U.S.D.A. Eastern Washington Cooperative River Basin Study
Source:
Base map prepared by SCS, W/ISC, Carto Staff from U.S. Forest Service compilation.
Thematic detail compiled by U.S. Forest Service.
U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE



LOCATION MAP

LAND EROSION AND SEDIMENT YIELD

ENTIAT RIVER BASIN

CHELAN COUNTY, WASHINGTON

APRIL 1978

SCALE 1:200,000

M7-SN-23516-9

Land Erosion and Sediment Yield

The Land Erosion and Sediment Yield Map depicts 16 distinct erosion areas. Forest land and agricultural land erosion and fluvial sediment distribution are shown in the two map tables. The forest land area with the highest erosion rates are those which are named on the map. These are the areas most severely burned in 1970. Also, see Physical Water Quality Discussion, Appendix.

Sediment Distribution

Figures 14, 15, and 16 show mean annual fluvial sediment yield for streams within the 1970 burn area and selected points in the Entiat and Mad Rivers.

Recent riprap of Lower Entiat streambank to control erosion and land loss.

Figure 14.—Mean Annual Fluvial Sediment Distribution

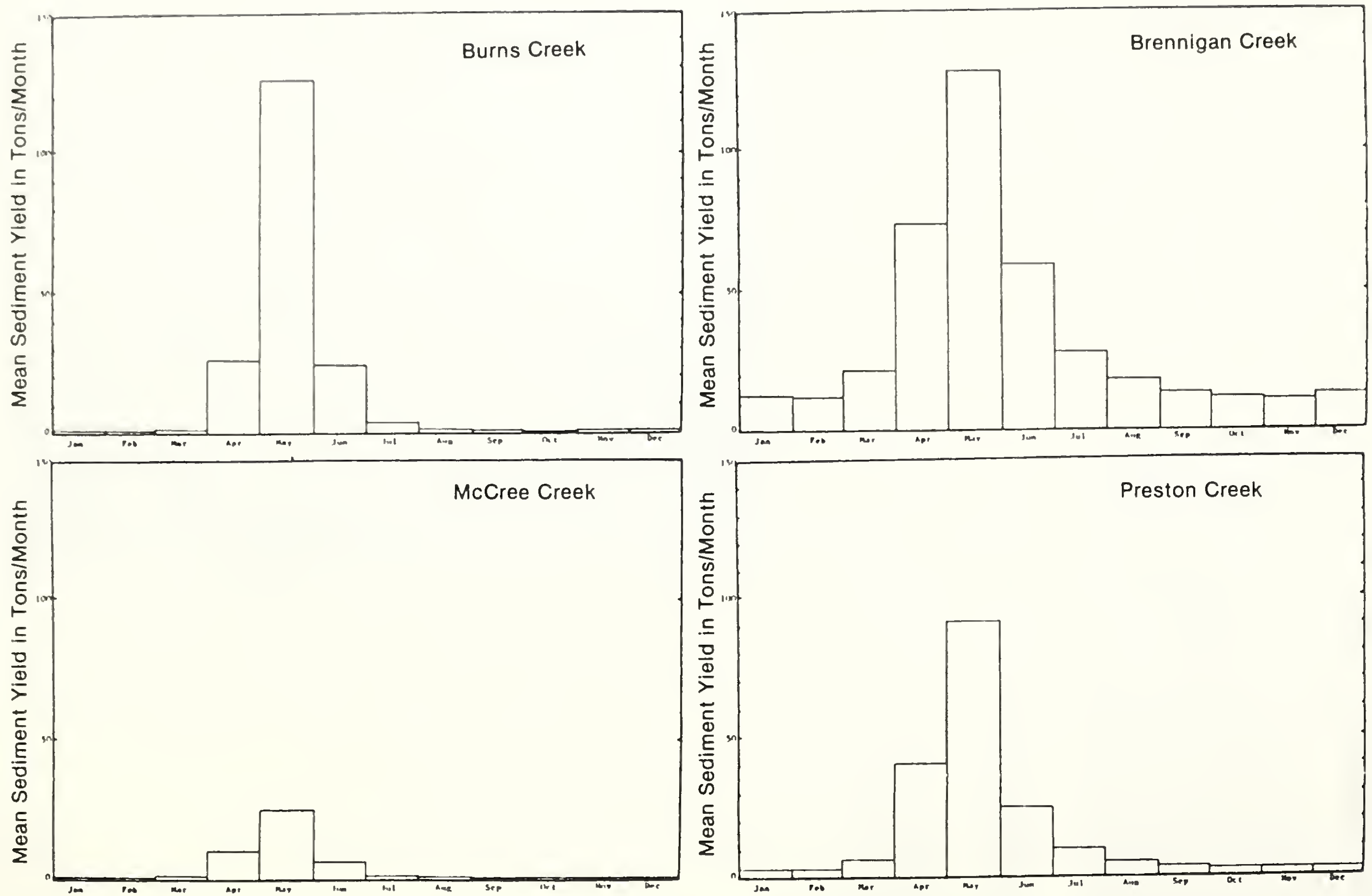


Figure 15.—Mean Annual Fluvial Sediment Distribution

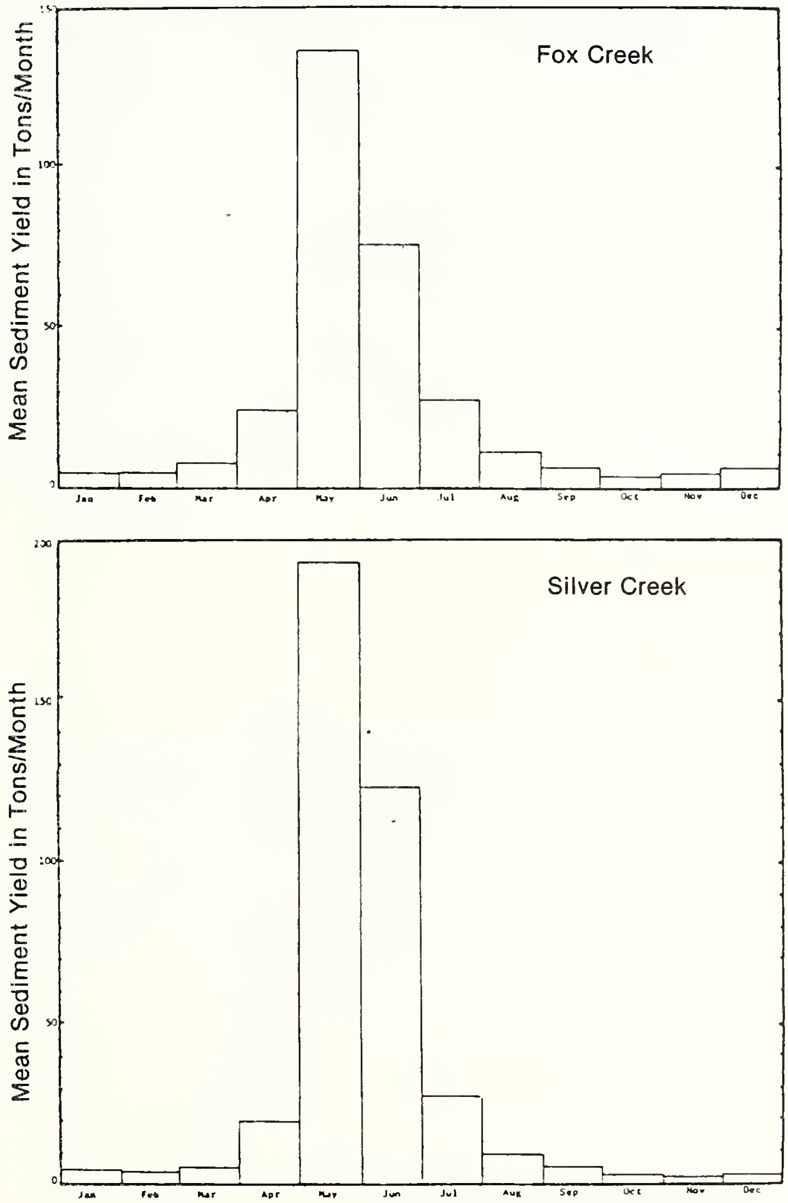
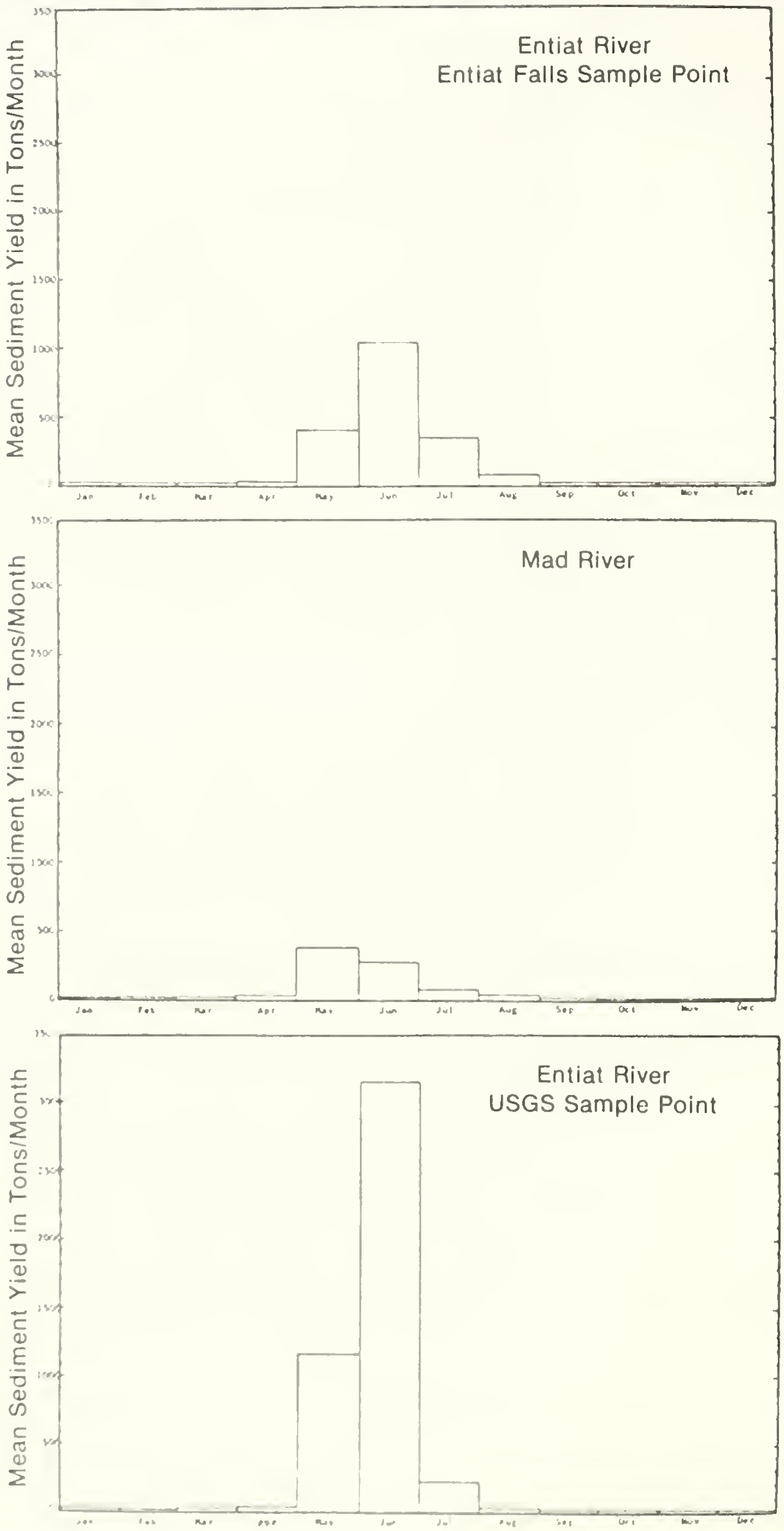


Figure 16.—Mean Annual Fluvial Sediment Distribution



Rill erosion on forest road in the Mad River area.

Sheet erosion pedestals on road cut slope in Mad River area. Note deer which have increased in numbers since 1970 fire.

Stream Flow - Sediment Production Regressions

The following Figures 17 and 18 are regression correlations between streamflow (cfs) and fluvial sediment production (tons/day) for selected forested sub-watershed units in the Entiat River Basin. These regressions were developed from paired streamflow and sediment data using a Price AA flow meter, depth integrated sediment sampler, and Helie Smith bedload sampler. The data was analyzed using a computer program available at the U.S.F.S. Wenatchee Hydrology Laboratory. The coefficient of determination (R^2) for the regressions ranged from .39 to .99. Generally, the better correlations were in the larger watersheds or those least affected by dry ravel soil creep into the intermittent stream channels during the summer months. One variable affecting the (R^2) for stations on the main Entiat River is the large volume of in channel sediment storage from previous runoff events.

Rock lined ditch through pumice soil has reduced downcutting and enabled grass to get a start.

Figure 17.—Sediment Discharge Relationships

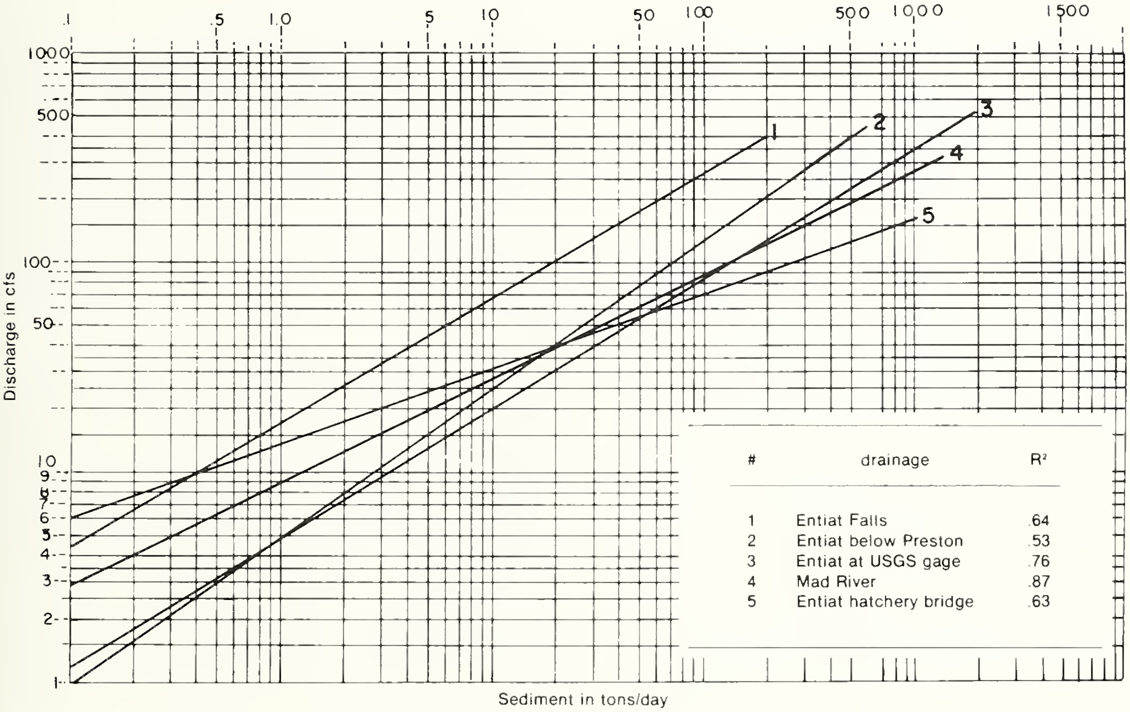


Figure 18.—Sediment Discharge Relationships

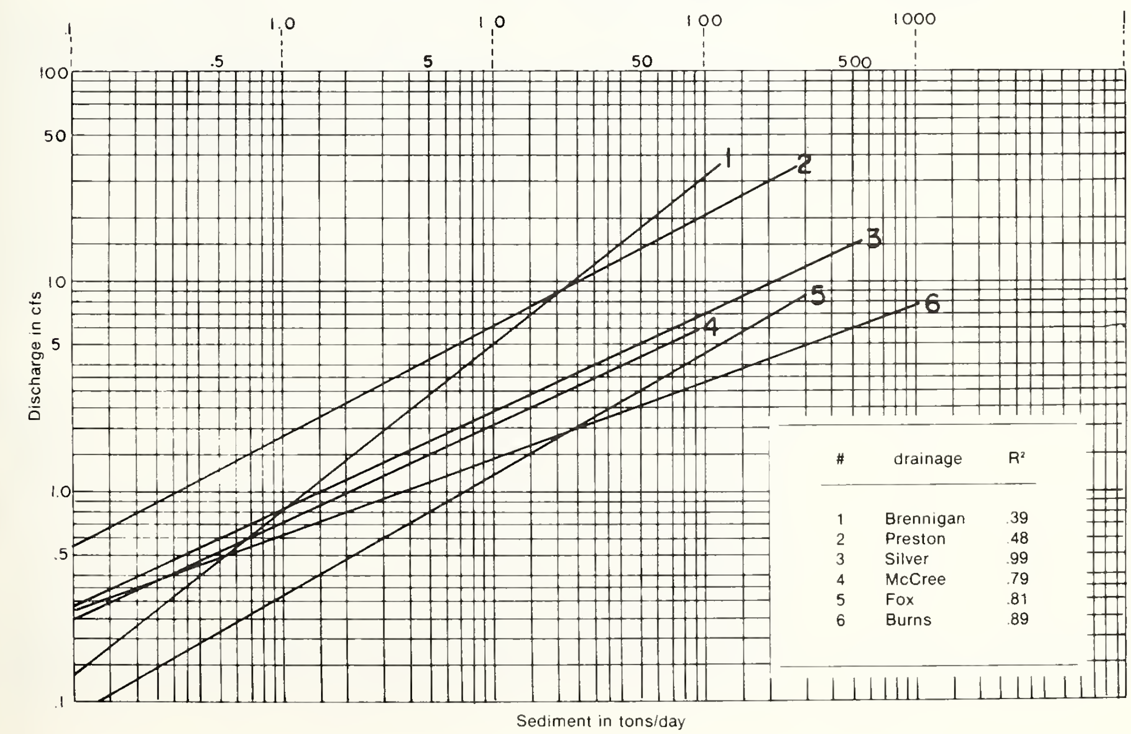


Figure 19.—Mean Annual Hydrographs for the Entiat Basin
Water Years 1961 - 70

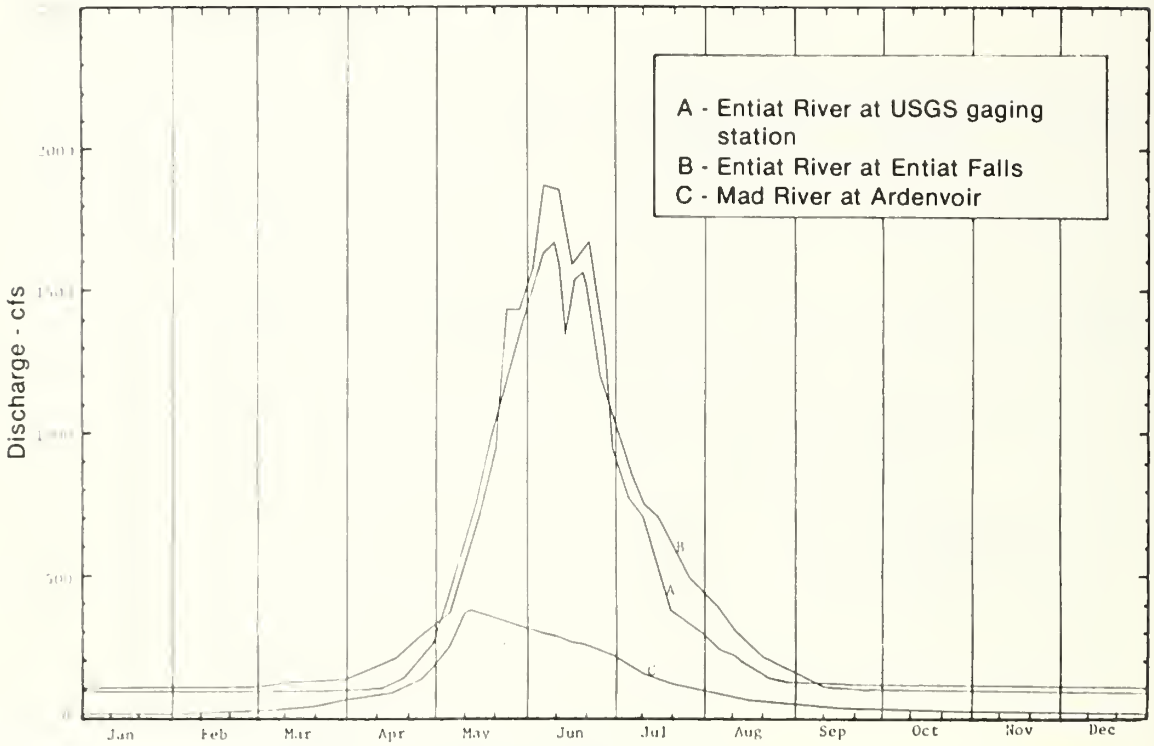
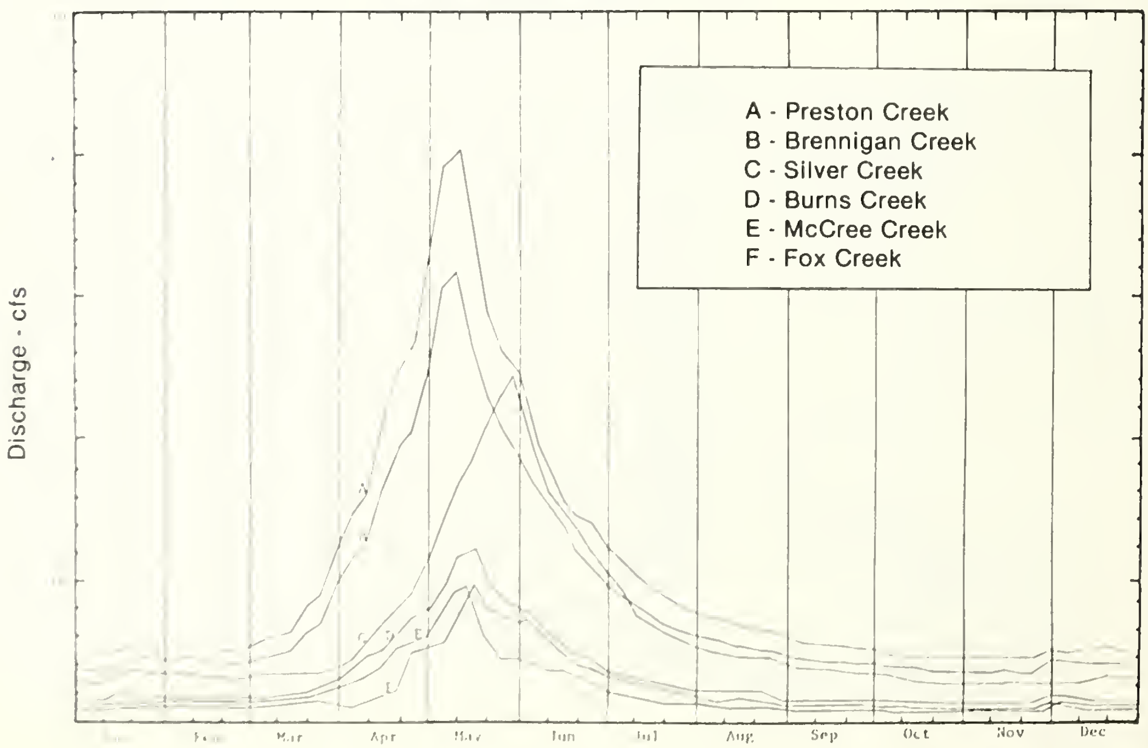


Figure 20.—Mean Annual Hydrographs for the Entiat Basin
Water Years 1961 - 70



Suspended Sediment - Turbidity Relationship

Turbidity data collected in the disturbed small mountain tributaries had no relationship to stream flow or sediment concentration. This was observed in the field and laboratory and can generally be explained by their very poor channel stability and active dry creep erosion process. During the dry summer months colluvial erosion loads the stream with colluvial fan material, priming them for flushing by the first rain — no matter what its magnitude.

The larger stream systems did, however, exhibit some relationship between turbidity (NTU)[1] and suspended sediment load (tons/day). Figure 21 illustrates this point as a regression line between turbidity and suspended sediment for two stations: (1) U.S.G.S. sampling station Entiat River at Ardenvoir below most of the severe burned area and (2) U.S.F.S. sampling station, Entiat River at Entiat Falls, above most of the disturbed area.

Figure 21 points out that a turbidity of 2 NTU above the burn produces about 60 tons per day of suspended sediment — while below the burn the same turbidity produces only 4.4 tons per day of suspended sediment. Since the data for these regressions were collected the same year, months, and by the same persons using equal equipment in the field laboratory and from the same river (different reaches), much of the error and bias is eliminated.

Why then such a difference in quantities? It is explained by microscopic examination of the filtered sediments. Above the burn the sediments are typically coarse grain particles which produce low turbidity readings per mass weight. Conversely, down below the burn area much fine grained glacial silt, ash, and pumice was observed which produces very high turbidity readings but has a disproportionate mass weight in terms of tons of sediment.

[1]NTU - Nephelometric Turbidity Units are considered comparable to the previously reported Formazin Turbidity Units (FTU) and Jackson Turbidity Units (JTU) - Manual of Methods for Chemical Analysis of Water and Wastes, EPA, 1974.

Sedimentation and bank scour following the 1977 Crum Canyon floods.

This exercise is perhaps academic but serves to point out two important considerations:

1. Any relationship between sediment and turbidity is only reliable at the point of data collection and cannot be extended up and down the same river.

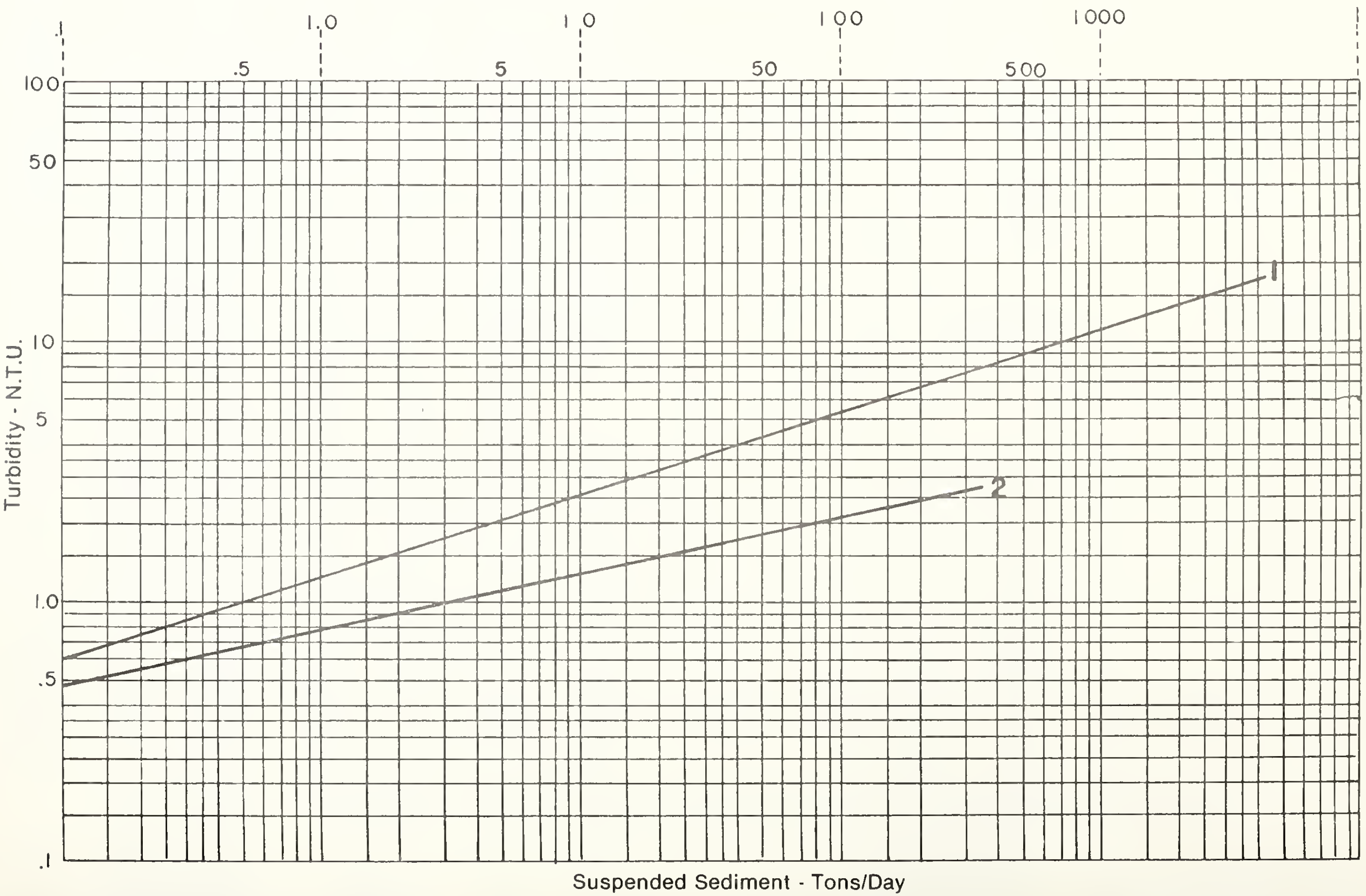
2. Turbidity data tells very little about the dynamics of any river — even a relatively clear stream can be carrying tremendous loads of fluvial sediment right before your "5 NTU" eyes.

The significance of sediment data as opposed to turbidity data is made clear when the sediment-discharge relatioship (Figure 17) is analyzed for a discharge of 100 cubic feet per second. See example following:

Data Station Location	Discharge cfs	Sediment Tons/Day
Entiat Falls (above fire)	100	19
USGS at Ardenvoir (below fire)	100	130

Floodplain encroachment continues to be a land use planning problem along the Entiat River—particularly due to unstable channels and increased runoff following destruction of 106 square miles of forest vegetation.

Figure 21.—Turbidity - Suspended Sediment Relationship
(1) USGS Station - Entiat River at Ardenvoir, WA
(2) USFS Station - Entiat River at Entiat Falls, WA



Note: These regressions only good
for these stations.
Data Base 1977

By C.R. Benoit 3/14/78
Data Source: USFS 1975-77
r^2 = .87 and .84

Chemical and Biological Water Quality

Water chemistry and biology has not changed a great deal since the 1970 fire due to land disturbance. An understanding of prefire water quality conditions is outlined in a paper entitled "Climate and Hydrology of the Entiat Experimental Forest Watershed Under Virgin Forest Cover," by Helvey, Fowler, Klock, and Tiedemann.

The prefire watershed calibration data presented in this Report indicate that watersheds were stable under forested conditions and that streamflow was extremely pure chemically.

As an overview of how the water quality production from the Entiat River exists today, data from the U.S. Geologic Survey at the mouth of the Entiat River is presented for water year 1976. It is important to realize this data reflects both the forest land (96.5 percent) and agriculture land (3.5 percent) base. The agriculture use is primarily domestic grazing and fruit production. Many of the streambank segments along the main Entiat River in the agriculture environment have become unstable due to increased stream flow. Likewise, increased bedload and log debris have accelerated lateral channel migration.

U.S.G.S. Entiat River Water Quality

Location: NW ¼ SE ¼ sec. 18, T. 25 N., R. 21 E., 1.2 miles west of Entiat School — River Mile 1.4

Drainage Area: 419 square miles

Period of Record: October 1975 through September 1976

Cooperation: U.S. Geologic Survey and Washington State Department of Ecology

Nutrients

A more detailed discussion of postfire nutrient concentrations and results from burn revegetation with fertilizers is located in a publication entitled, *"Some Climatic and Hydrologic Effects of Wildfire in Washington State,"* by Helvey, Tiedemann, and Fowler. In summary, it was found that on the Entiat Experimental Watersheds no effects of fire or postfire erosion control fertilization were detected in quality of water for municipal uses. Even though concentrations and total losses of constituents (primarily nitrate-N) increased considerably, there has been no adverse effect on the future productivity of these ecosystems because the soil is still able to conserve applied nutrients.

Water Quality Data, Water Year October 1975 to September 1976

DATE	TIME	INSTANTANEOUS DISCHARGE (CFS)	SPECIFIC CONDUCTANCE (MICROMHOS)	PH (UNITS)	TEMPERATURE (DEG C)	COLOR (PLATINUM-COBALT UNITS)	TURBIDITY (JTU)	DISSOLVED OXYGEN (MG/L)	IMMEDIATE COLIFORM (COL. PER 100 ML)	FECAL COLIFORM (COL. PER 100 ML)	TOTAL NITRITE PLUS NITRATE (N) (MG/L)	TOTAL AMMONIA NITROGEN (N) (MG/L)	TOTAL PHOSPHORUS (P) (MG/L)	DISSOLVED ORTHO. PHOSPHORUS (P) (MG/L)
OCT														
21...	1015	192	84	6.5	7.3	21	3	12.0	B700	78	.09	.10	.02	.00
28...	1025	164	87	7.4	5.1	21	5	12.4	400	B2	.15	.06	.02	.01
NOV														
11...	1010	255	76	7.7	2.4	13	2	14.3	B100	B4	.07	.03	.00	.00
18...	1025	329	67	7.5	.8	13	1	14.7	310	B6	.07	.02	.01	.00
DEC														
09...	1010	908	62	7.9	3.9	13	4	13.0	B120	<2	.05	.03	.02	.00
16...	1030	714	67	7.4	.1	8	2	14.5	110	<2	.07	.06	.02	.00
JAN														
06...	1025	362	88	7.4	.0	8	3	14.1	130	B12	.11	.11	.02	.01
20...	1015	341	84	7.3	.1	4	2	15.0	44	B10	.08	.05	.01	.01
FEB														
03...	0925	277	83	7.4	1.4	13	3	13.8	46	<2	.08	.06	.01	.00
24...	1015	273	94	8.0	3.0	9	3	14.5	B34	<2	.03	.04	.02	.00
MAR														
09...	1010	222	93	7.4	3.6	4	4	14.1	>74	<2	.04	.02	.01	.00
23...	1005	266	113	7.3	4.4	4	2	13.2	420	B120	.06	.03	.02	.00
APR														
13...	1035	690	95	7.7	6.8	17	8	12.5	210	10	.03	.05	.03	.00
27...	1010	531	105	7.6	8.3	17	6	11.9	B120	2	.01	.03	.02	.00
MAY														
11...	1035	2300	45	7.3	7.6	17	10	12.0	180	2	.06	.05	.07	.05
25...	1000	1860	47	7.0	7.3	13	4	12.1	42	<2	.04	.02	.03	.00
JUN														
08...	1045	1360	50	7.3	9.8	13	7	11.5	100	12	.02	.02	.02	.00
22...	1010	2310	38	7.3	8.6	4	6	12.0	B80	<2	.03	.04	.03	.00
JUL														
13...	1000	1670	40	7.3	10.1	13	4	11.6	B200	B2	.03	.04	.02	.00
27...	1010	1120	50	7.4	10.7	13	4	11.3	52	B2	.04	.08	.02	.00
AUG														
10...	1020	726	51	7.3	13.1	13	3	10.6	590	120	.02	.09	.03	.01
24...	0950	430	64	7.7	14.2	8	2	10.4	780	B20	.02	.02	.01	.00
SEP														
14...	0945	219	83	7.7	12.0	8	1	10.9	B300	B2	.07	.02	.01	.00
21...	1000	222	83	8.0	13.1	13	1	10.8	180	B18	.02	.02	.01	.00

B Results based upon colony counts outside the ideal range.

Problems on Agricultural Lands

The preceding analysis describes and quantifies problems affecting the entire Basin. Most of these occur on forest lands and are upstream, above most water users. There are also the same problems of erosion and sedimentation occurring on nonforest lands.

Sheet and Rill Erosion

Sheet and rill erosion are not serious problems on most privately owned agricultural lands. Almost all of the 1,271 acres of orchard are protected with grass cover crops and irrigated with sprinkler systems. The 329 acres of irrigated hay and pasture also have dense stands and are generally not subject to sheet and rill erosion. The 300 acres of nonirrigated cropland are subject to moderate sheet and rill erosion. These areas are most erosive during years when the land is in winter wheat following summer fallow (every other year). It is estimated that annual erosion rates from these areas average 0.5 tons per acre per year.

Rangeland areas in the Basin are subject to severe sheet and rill erosion problems if grazing is not properly managed. If the rangeland is well-managed and has good vegetative cover, problems with water erosion should be minimal. Average annual erosion rates from rangeland are estimated at less than 1 ton per acre per year since most rangeland is not used heavily and is in excellent condition.

Burned over rangelands experience severe soil losses during high intensity summer rainstorms. During the Crum Canyon storm in June 1977, soil losses were measured at 90 to 117 tons/acre. These losses occurred primarily on 2,350 acres of Federal land. An estimated 251,450 tons of soil were lost during these storms.

Table 19.—Estimated Annual Sheet and Rill Erosion Agricultural Lands — Entiat River Basin

Land Use	Acres	Erosion Rate Tons/Acre	Average Annual Erosion Tons
Irrigated Orchard	1,271	.10	127
Irrigated Hay and Pasture	329	.10	33
Nonirrigated Cropland	300	.50	150
Nonirrigated Pasture	744	.25	186
Rangeland	8,979	.75	6,734

Stream Channel Erosion

Erosion of stream channels during spring runoff and after high intensity summer storms is a major problem for agriculture. Approximately 2,940 feet of riverbank, fronting orchard, are subject to severe channel erosion. An additional 9,250 feet has channel erosion problems of a less severe nature, but provides some threat to several hundred additional acres of orchard and irrigated pasture lands.

These eroding stream channels claim an average of 79 tons of streambank each year. It is estimated that 95 percent of this sediment enters the Columbia River. Where the Entiat River flows through orchard and irrigated pasture areas, the stream gradient is less than in upland forested areas but is still significant. The stream descends from an elevation of about 1,250 feet at Ardenvoir to approximately 700 feet at its confluence with the Columbia River at Entiat, about 9 miles downstream, an average of 78 feet per mile.

The Lower Entiat has a natural tendency to meander, which increases erosion hazard to floodplain banks. Brush, grass, and tree roots are the main source of bank stability in this area. If they are removed by water, mechanical means or grazing livestock, erosion and sediment delivery are accelerated.

Problem Effects

In initiating this Study, the Entiat citizenry expressed their concerns in a Problem Chart (Appendix B). The chart, developed during a community meeting, noted possible short-range and long-range solutions and differentiated between what were called upstream and downstream problems.

Upon analysis it became apparent that these identified concerns were symptoms of more basic problems with the Entiat Basin System. These were defined and quantified in the preceding section.

Solution of upstream problems will do much to resolve downstream problems. However, resolution of downstream problems will also require certain on-site measures. Figure 1 shows the cause and effect interrelationship of problems within the Basin. Possible solutions to these are discussed in the Alternatives Section. Following is a discussion of downstream problems. These are the adverse effects of high runoff, erosion, and sediment which directly affect those living in the Basin.

Flooding (Loss of Agricultural Land and Crops)

The River Basin has been studied in detail for flood hazard alanysis by the U.S. Department of Housing and Urban Development (HUD). Potential flood hazard levels have been delineated for 10, 50, and 100-year frequency floods. Contractor for the study was CH_2 M Hill, Bellevue, Washington. Results of this Study show that 84 acres of orchardland are subject to 100-year frequency floods (see Floodplains and Orchardland Map).

The HUD Study details the nature of the flooding problem. The 50-year flood inundates approximately the same acreage as does the 100-year event.

Chelan County has adopted regulations that should be effective in minimizing future damages along the main stream system. These regulations currently request all new buildings to be at an elevation of at least 2 feet above the 100-year flood.

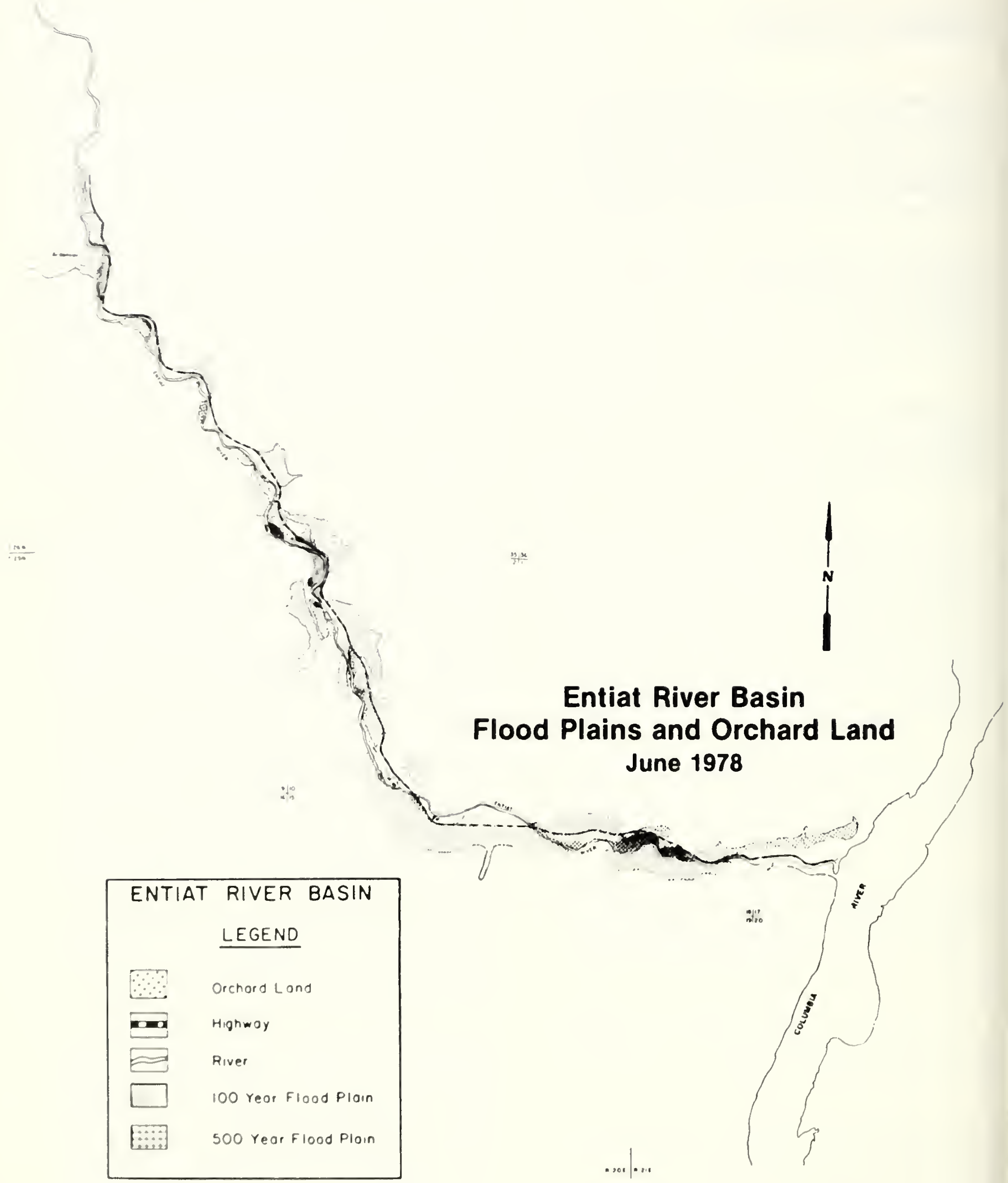
Analysis indicates that the 10-year flood is mostly contained within the river channel. The chief effect is channel erosion.

Average annual loss of agricultural land through streambank erosion has been 1.5 acres. Normal annual erosion accounts for 0.5 acres per year, and storm events cause an additional 1.0 acre loss per year. For example, during the 1972 flood, (a 2 percent 50-year flood) over 10 acres of orchardland were lost.

Approximately 200 acres of prime orchard is exposed to such erosion. The loss of an acre of orchardland represents an annual loss of income as well as the value of the land. Table 20 shows the present value of an acre of 60 percent apples and 40 percent pears in the Entiat Basin. These values have been computed over a 100-year period to correspond with other report material. Note that the average annual net benefits are $425.72 per acre. An analysis of average farm pear and apple prices for the period 1969 through 1973 results in average revenue of $2,625.49 per acre. Orchardland is valued at approximately $5,000 per acre. However, the acre cannot be regained through development of new orchards within the Basin due to climatic limitations. Therefore, the real loss is difficult to assess.

The damage that a particular flood event will do is not predictable. Following is a brief summary of damages attributable to past events.

In June 1972, 325 acres of agricultural land was damaged by flooding following a heavy rain. Irrigation systems in the Basin were damaged extensively. Stream channel erosion on an estimated 37,000 feet of steambank resulted from the flood. Another flood occurred in the spring of 1973, but damages were less severe. An estimated 5 acres of orchardland were flooded and five irrigation pump locations were destroyed by ice in the stream during January runoff.



Entiat River Basin
Flood Plains and Orchard Land
June 1978
N
ENTIAT RIVER BASIN
LEGEND
Orchard Land
Highway
River
100 Year Flood Plain
500 Year Flood Plain
COLUMBIA
RIVER

Table 20.—Present value of net returns per acre, 60% apples and 40% pears, Entiat Basin

Year	Annual Revenue	Annual Cost	Annual Net Return	Discount Factor (6.625%)	Present Value
	Dollars			Percent	Dollars
5[1]	——	981.36	(981.36)	.725	(711.49)
6	——	426.31	(426.31)	.680	(289.89)
7	118.86	648.28	(529.42)	.638	(337.77)
8	551.06	874.95	(323.89)	.598	(193.69)
9	1,307.06	1,271.52	35.54	.561	19.94
10	2,192.85	1,520.28	671.57	.526	353.77
11	2,322.64	1,528.90	793.74	.493	391.31
12	2,625.49	1,616.16	1,009.33	.463	467.32
13	2,625.49	1,607.28	1,018.21	.434	441.90
14	2,625.49	1,597.64	1,027.85	.407	418.33
15	2,625.49	1,587.19	1,038.30	.383	397.67
16	2,625.49	1,575.84	1,049.65	.358	375.77
17	2,625.49	1,563.54	1,061.95	.336	356.82
18	2,625.49	1,550.18	1,075.31	.315	338.72
19	2,625.49	1,535.70	1,089.79	.286	311.68
20	2,625.49	1,519.98	1,105.51	.269	297.38
21-100	2,625.49	1,507.22	1,118.27	3,900	4,361.05[2]
					6,415.48[3]

[1]It was assumed that the new orchards will not be planted until 5 years after damaged land has been restored.

[2]Present value for years 21 through 100.

[3]Average annual net benefits amortized over 100 years is $425.72.

In June of 1974 severe flooding occurred again. The River was at flood stage for several days as snow in the upper Watershed melted.

On June 13, 1977 a high intensity, short duration thunderstorm occurred in Crum Canyon. This local storm delivered approximately 2 inches of precipitation in 30 minutes. Hail accompanying the storm at the 3,500 foot elevation was reported at 4 to 6 inches in depth. This storm was followed by another in the same area on July 25. The two storms damaged 3,834 acres; 3,184 National Forest, and 650 acres of private lands. The resulting runoff from these storms caused rilling and channel scour on 3,834 acres. Twelve irrigation systems and eight domestic water systems were damaged by the flood. Sediment was deposited on 25 acres of orchard and 15 acres of irrigated hayland by the flood waters. ASCS requested $250,000 for debris removal on private farmland and other emergency conservation measures.

Deposit of Sediment

Some effects of sediment deposition are discussed in other sections. Deposition on fish spawning gravels, for instance, is noted under the Section, Degradation of the Fishery. Other instream effects include the diversion of currents into banks, causing accelerated bank cutting and subsequent land loss and further sedimentation. Much of this deposition is noted on the Critical Erosion and Rehabilitation Needs Map.

Another significant effect is that much of the sediment reaching the system is ultimately deposited in the deep channel at the mouth of the Entiat. The restoration of this channel is of interest to many Entiat residents. Benefits of sediment removal include improved fish habitat, increased recreational opportunities, visual attractiveness, and reclamation of soil suitable as fill material and for agricultural purposes.

The area of deposition referred to here extends from the Entiat mouth upstream ½ mile. This section of the Entiat River is within the permit areas of the Chelan County P.U.D. The level of the River through this stretch is directly influenced by Rocky Reach Dam. During periods of high runoff, especially those that correspond with a full pool condition of Lake Entiat, the low-lying lands flood. This floodplain is currently used by casual recreationists. A remnant road provides easy access just upstream of the highway bridge with room to park a few cars.

The Chelan County P.U.D. Exhibit R, (Recreation Plan) approved by the Federal Power Commission in 1976, proposed a minimum development for this area. The existing road is to be improved and the flat graded and shaped to accommodate parking. The objective is to create an opportunity for winter and summer activities suitable for the space available while keeping improvements at a minimum and of a type which will withstand periodic flooding. The total investment planned probably will not exceed $15,000.

Boating facilities are not planned here because of the limited area for parking development and because of potential conflicts with people fishing in the Entiat channel. A boat launching area is being built on Lake Entiat about a mile north of the Entiat mouth. Washington State Shoreline Permits have been obtained for these projects and NEPA requirements have been met.[17]

Sediment in Irrigation Systems

The Soil Conservation Service conducted a study to determine damage due to sediment. In the fall of 1976, an agricultural economist interviewed orchardists and others. Sediment damages in this report are not refined to an extent which would make them suitable for specific project planning purposes. However, the data reflects the situation and will serve as a preliminary investigation report for specific remedial project proposals. A summary of his findings are in Table 21. His analysis is in the Appendix.

Table 21.—Damage to Irrigation Systems

Item	Annual Cost		
	Before Fire	After Fire	Increase
Irrigation Systems			
Sprinklers	$147,390	$256,960	$109,570
Pumps	21,600	92,000	70,400
Ditches	1,070	10,720	9,650
Subtotal	$170,060	$359,680	$189,620
Lost Value through Crop Reduction			127,100
Total			$316,720

Irrigation water diversion on the Lower Entiat. Sediment has caused costly maintenance to irrigation systems since the 1970 fire and 1972 flood.

Degradation of the Fishery [18]

The comparison of pre and postflood spawning ground surveys, conducted yearly in the 6-mile index section downstream from Fox Creek (River Mile 27.7), is the best method of assessing effects of the 1972 flood and resulting gravel contamination on spring chinook production. From 1962 through 1974 the index areas redd (salmon nest) counts ranged from 384 to 61, averaging 171 redds annually. In 1976, the first adult return impacted by the 1972 flood, only 47 redds (27.5 percent of average) were observed in the index area.

Survival of eggs deposited in the Entiat River in 1972 was very poor. The adult return in 1977, the product of spawning in 1973, displayed a marked improvement with 171 redds (exactly the 13-year average) observed in the index area. Furthermore, unlike 1976 when the Columbia River was completely closed to spring chinook harvest, commercial and sport fisheries harvested approximately 42,000 spring chinook in 1977. Although with just 2 years' data it is difficult to establish trends. It appears the Entiat river reach is going through a natural rehabilitative process, particularly in the upper reaches where spring chinook spawning occurs. Visual observation during spawning surveys confirm this fact. Spawning riffles which were completely inundated with a layer of silt and sand in 1972 are now returning to their original composition. Fortunately, the 1977 floods and earth

Federal fish hatchery in Lower Entiat takes some of its water from the river. Major fish losses have occurred due to river sediment. Hatchery plans to change to a groundwater source of clean water.

slides in Crum Canyon affected only the lower Entiat River and, therefore, did not impact the spawning area.

Since 1971, the Entiat Hatchery has been subjected to river runoffs which have brought considerable amounts of debris and silt into the hatchery rearing facilities. The hatchery staff has expended the following estimated number of hours cleaning out facilities following these runoffs:

	Man Hours	Total Clean-out Costs/Year
1971	48	$ 480
1972	296	2,960
1973	51	510
1974	79	790
1975	48	480
1976	0	0
1977	600	6,000

Until 1977 hatchery personnel could not attribute any substantial mortality of fish at Entiat *directly* to sediment-laden runoff waters. However, losses have occurred that were *indirectly* caused by runoff. During periods of high runoff it becomes impossible to feed the fish due to high turbidity. Lack of food coupled with mechanical abrasion of the fishes' gill tissue by particulate matter often leaves the fish in a weakened condition and susceptible to diseases. Following heavy runoffs disease problems are more severe and fish mortalities do increase.

Also, when fish are not fed properly, their growth is retarded. If the period without food is prolonged, the fish will fail to reach smolt size and will not migrate to the ocean.

The Entiat Hatchery experienced a high runoff on June 13, 1977. Cleanup from that event had barely been accomplished when a second flood hit on July 25. The floodwaters on the second runoff contained such a high sediment load that they filled rearing ponds and partially plugged the main 30-inch diameter water intake pipeline. This resulted in a loss of 800,000 spring chinook salmon approximately 4 inches long which represented about 2/3 of total fish production at the Entiat Hatchery. The death of these fish represents a direct monetary loss of about $35,000. The loss in benefits these fish would have provided to the Columbia River and offshore fisheries is in the magnitude of $457,600. In addition to this economic loss, emergency repairs were necessitated and alterations to the pipeline system at Entiat will cost in excess of $9,100. These repairs are directly related to the recent flood from Crum Canyon.[19]

Table 22 summarizes the findings of a report compiled by the Washington State Department of Fisheries, using dollar values from a National Marine Fisheries Service study of the Columbia River. Data on numbers of fish returning are from a 1-year record.

Table 22.— Value of Fish Lost
Due to Sedimentation in Entiat River

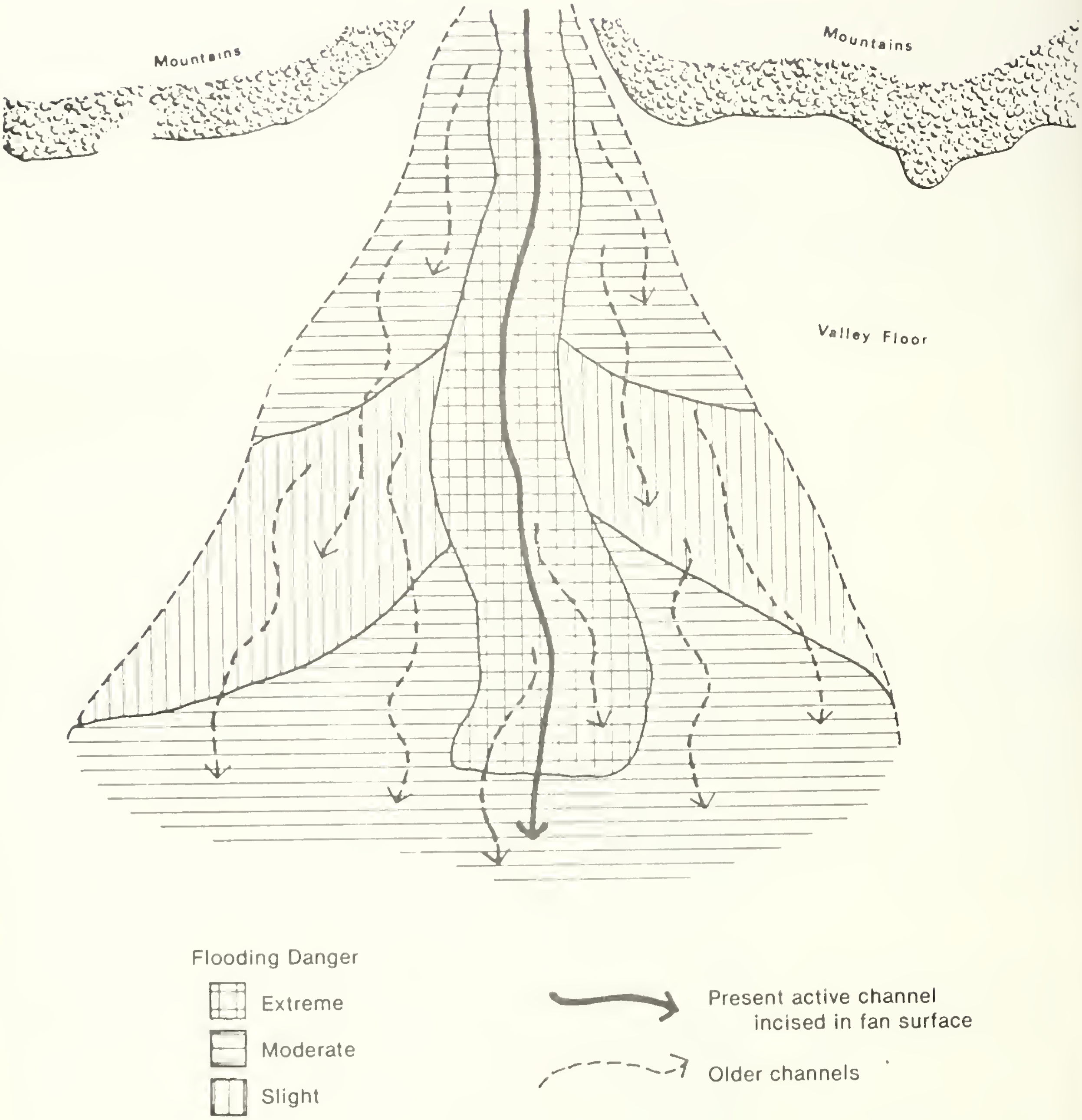
Species	Annual Damages
Salmon	$ 65,840
Steelhead	63,130
Total	$128,970

The report from the Department of Fisheries shows an average of 1,122 spring chinook returning to Entiat River each year between 1968 and 1975. The 1976 counts are the first returns that could have been influenced by the 1970 fire and the 1972 flood. These returns show a 50 percent reduction or 458 fewer fish than the previous 8-year average. Average annual damage to the spring chinook run is $65,840 (458 fish x $143.76/fish).[20]

A report by Dick Allen, Department of Fisheries, states that steelhead runs have averaged 846 fish. Their report does not state the reduction of steelhead in 1976, but it is assumed this run would also be reduced 50 percent.[21] (423 fish x $149.24 per fish = $63,130 average).[20]

Total Average Annual Damage to the Fishery Resource = **$128,970.**

Figure 22—Flood Danger Zones on a Typical Alluvial Fan[1]



[1]From Cooke and Doorkamp, 1977.

Drinking Water Quality

The concern for drinking water expressed by Entiat Valley residents was primarily due to the Ardenvoir System. This privately owned system supplies water to the mill at Ardenvoir, approximately 14 families in the community, the store and restaurant. The Gold Ridge Fire damaged the Tillicum Creek Watershed and undoubtedly increased sediment at the intake on Mad River. Apparently this increase strained a system which was already inadequate because of age. The system is owned by Pack River Co. In 1975, because all samples tested positive for *E. coli* bacteria, they renovated the intake and supply system and installed a new chlorinator. The system has no filtration. It uses a 12-inch diameter redwood stave pipe for retention, storage, and chlorine dispersal.

Since renovation, bacteria tests have been negative and the system is considered to meet requirements of the Chelan County Department of Environmental Services.[22]

Public Safety

In spite of the inherent hazards of alluvial fans, their relatively level terrain and proximity to the River make them especially attractive to individuals seeking recreational residence sites. In June 1972, a debris avalanche and flood occurred on one such fan, killing four people and destroying several cabins. Chelan County has been concerned with preventing a recurrence of this type of disaster. They have defined the floodplain and developed an ordinance and building codes to prevent further damage.

Flooding on alluvial fans has long been a problem in the Entiat Basin. Rapid sediment transport and consequent alluvial fan development during abnormally high flows is a natural erosion process characteristic of this physiographic region. Steep slopes, sparsely vegetated shallow soils, and frequent high intensity storms all contribute to the relative instability of the land. Fan formation and flooding in the upper Entiat was accelerated by glaciation and recently by devegetation from wildfire.

The fans of the lower, unglaciated portion of the valley are typical of those found in arid mountainous regions. Fans form where sediment-laden streams emerge from the mountains onto a valley floor or river floodplain. A change in the hydraulic geometry of the stream occurs: flows increase in width, decrease in depth and velocity, and deposition results.[23]

In the glaciated upper Basin, (above Potato Creek) the same hydraulics are at work as in the rest of the Basin, but have been accentuated by glacial erosion. During the Pleistocene Epoch, glacial scouring of the main valley truncated the smaller tributaries and left them "hanging." These hanging valleys are typical of glaciated regions as are the waterfalls and alluvial fans which occur at their mouths. Valley truncation accelerates the erosive ability of a stream. After glaciation, the tributary streams cascade down the steepened valley wall forming a notch which eventually enlarges into a ravine. Rock and soil debris is dumped on an alluvial fan beneath the falls. The stream will continue to wear down its channel to the lowest possible level.

There are several problems associated with flooding on alluvial fans in the Entiat Basin. First, although these fans are subject to flooding, there is low flow at most times so that the likelihood of flooding is often minimized or ignored. Secondly, flow on alluvial fans is characterized by high sediment concentrations causing viscous flow capable of moving boulders and log debris. Thirdly, the channels followed by floods change from time to time; for example when a channel becomes blocked by debris, thus causing a shift in hazard zones.[23] (See Figure 22).

The flood hazard on these fans (see Surface Geology and Flood Hazards Map) is further substantiated in a report by E. R. Artim, Washington State Department of Natural Resources entitled **Flood Hazards of Part of Chelan County, Washington,** 1974 (Appendix D).

Visual Resource

The degradation of aesthetic values is difficult to quantify because of varying perceptions of what is desirable. There have unquestionably been pronounced changes in the visual character of the Basin as a result of the fires, subsequent erosion, sedimentation, and remedial measures taken to deal with these. The importance of the visual resource is recognized by the community and stated in the Problem Chart (Appendix). Of course, a pleasing atmosphere in which to live and work is desirable. The visual resource is also closely tied to recreation use and, therefore, has economic implications although they cannot be quantified. Prior to 1970, the characteristic landscape was one of orchards leading upstream to dense stands of large Douglas-fir and pine. A screen of hardwoods permitted glimpses of the River, rock outcrops, and the coniferous forest rising above. The impression was one of a cool, shady, forest environment.

Today approximately one-third of the Basin is left open, with snags evidencing catastrophic forest fire. There are large areas of ceanothus and other brush. Burnt areas have limited visual variety. Road embankments, banks and areas of bare soil are exposed to view. Many rocks on side slopes and along eroded streams are visible. The exposed soil and rocks contrast sharply with adjacent vegetation and appear white and glaring. Scraggly trees within and adjacent to the burn catch the eye.

The clarity of the Basin's streams is reduced during periods of increased flow. During spring snowmelt, after storms, or as a result of slides, they become turbid and unattractive. The bottom of the Entiat River has been altered visually by sediment deposits which fill in and cover gravels, causing color changes.

Stream channels have been scoured and banks eroded, eliminating vegetation and leaving raw banks. Debris has been deposited in the stream, contributing to the overall disturbed appearance.

Remedial activities have resulted in piles of debris, raw excavation, soil mounds, and other evidence of activity along the River corridor. Rock riprap has added a harder visual line and contrasting color to the river bank. Similarly, salvage logging roads have introduced horizontal line and color contrast through open burn areas. The Basin's visual resource can be restored to one having the following characteristics:

A healthy, natural appearing variety of evergreen trees on the slopes.

Hardwood and evergreen trees along the River corridor framing views of scenic landscape features such as river views, rock outcrops, groupings of contrasting trees, and the mountains of the upper valley.

Vegetated banks and color contrasted areas.

A variety of trees of different age classes and species along the corridor providing sequenced viewing along the entire corridor.

A program to achieve this should include:

Reducing contrast of exposed tributary drainage.

Rehabilitation of contrasting bank edges and cut banks.

Rehabilitation of vegetation to thrifty, healthy green.

Provision for approximately 60 percent shade in burn areas along the Entiat Road.

Removal of slash, snags, and trees.

Introduction of vegetation along streams and alluvial fans.

Removal or screening of piles of debris, including those made by man.

A field guide for managing the visual resource of the Entiat Corridor was developed by Maekawa and Proebstle. Remedial activities in the Basin should be coordinated with this guide. Erosion and sedimentation objectives can often be met in a manner which is compatible with visual objectives. Often the cost is insignificant or greatly reduced if visual objectives are considered from the outset of project planning.

Recreation

Recreation use averaged 118,000 visitor days for all activities on National Forest land in the Entiat Ranger District during 1975 and 1976. This is a 20 percent decrease from the 1968-1969 average of 148,000 visitor use days. What part the 1970 fires and subsequent flooding played in this decline is not known. An attempt to quantify this and other economic impacts was made by Pieter Bakker in his 1974 thesis *Economic Impacts of Forest Fires, The Entiat Case*. However, use on other Wenatchee National Forest Districts averaged a 22 percent increase during the same period. Table 23 shows the percent change in use between preburn to postburn periods.

Table 23.—Comparative Recreation Use by Ranger District in Thousands of Visitor Days[1]

Ranger District	Thousands of Visitor Use Days						Percent
	1968	1969	Average	1975	1976	Average	Change
Entiat	131.3	164.2	147.8	115.5	120.4	118.0	− 20
Chelan	267.4	323.2	295.3	578.0	698.8	638.4	+ 116
Cle Elum	406.1	582.9	494.5	681.2	597.4	639.3	+ 29
Ellensburg[2]	470.9	620.9	545.9	449.4	445.5	447.5	− 18
Lk. Wenatchee	299.6	335.2	317.4	423.4	527.8	475.6	+ 50
Leavenworth	667.7	908.3	778.0	852.2	848.4	850.3	+ 8

[1]Visitor Day—As used in Forest Service recreation use tabulations, is equivalent to one person staying 12 hours, two persons staying 6 hours, etc.

[2]The indicated decline is probably due to a change in data collection procedures. District personnel feel that use either remained stable or increased slightly during this period.

Recreation use and development in the valley is becoming more prominent.

Chapter 4—Plan Development

Alternatives

The following presentation of alternatives addresses the basic problems affecting the Entiat Watershed. These basic problems are those discussed in the Problems Section of this Report. They are arranged under three separate objectives. These are 1) Fluvial Sediment Reduction, 2) Erosion Reduction — Land, and 3) Flood Protection. These alternatives are not diverse courses of action to be pursued. Rather they represent different levels of investment. For each level, an expected reduction of the problem objective is given. For each objective, the Without Plan Alternative is presented. This alternative means a continuation of established programs at current or currently planned levels. Other alternatives are an acceleration from this level.

These alternatives meet the objective of this Study; i.e., develop alternative means of reducing erosion and sedimentation, and minimize adverse effects of sedimentation.

In addition to these, certain single benefit alternatives are discussed. These address some of the problems covered in the Problem Effects Section of this Report.

It is important to note that the objectives used to display alternatives are not necessarily those of the Entiat Community. Development of a community objective is the next step.

Objective: Fluvial Sediment Reduction

Alternative 1:

(Without plan) Reduce the present fluvial sediment sources in the Entiat Basin to less than 32 tons/mile of stream channel. This is the approximate 1970 prefire sediment condition which resulted in an average sediment load of approximately 10,000 tons per year.

Remarks:

This is the "Without Plan" alternative for achieving pre-fire sediment levels. It assumes that current remedial program levels will be continued until work is accomplished. It also considers this program level in combination with the Basin's natural restorative processes.

Given these two assumptions, the objective will be reached in about 50 years. Nearly $1,000,000 will have been invested (in terms of 1978 dollars), and 409,275 tons of accelerated fluvial sediment would degrade water quality, aesthetics, aquatic life, and improvements.

Alternative 2:

Reduce present fluvial sediment sources in the Entiat Basin to less than 191 tons per mile per year from stream channels. This is about six times the preburn rate.

Remarks:

This alternative is formulated on the premise that the most severely erodible channel reaches in each stability class will be treated.

Channel Stability	Total Miles	Sediment[1] Rate Reduction Tons/Miles/Year	Treatment[2]	Tons of Sediment Reduced	Cost/Tons Sediment Reduced	Total Cost
Very poor	11	255	Plant trees, grass, brush 2 mi. at $1,500/ mile Rock riprap 9 miles at $50,000/mile	2,805	$161.50	$453,000
	11			2,805*		$453,000

*A reduction of 2,805 tons per year of fluvial sediment is 11 percent of the total present sediment load and a 17 percent reduction in the estimated 1970 postburn sediment load increase.

[1]Tons per mile of fluvial sediment reduction required to get below the alternative limit of less than 191 tons per mile per year.

[2]Riprap cost based on Corps of Engineer estimate of $10/cubic yard for Class II (2 feet thick) riprap. Revegetation based on 2.5 acres per mile and includes bank shaping.

Alternative 3:

Reduce present fluvial sediment sources in the Entiat Basin to less than 150 tons per mile per year from stream channels.

Remarks:

This alternative is formulated on the premise that the most severely erodible channel reaches in each stability class will be treated.

Channel Stability	Total Miles	Sediment[1] Rate Reduction Tons/Miles/Year	Treatment[2]	Tons of Sediment Reduced	Cost/Tons Sediment Reduced	Total Cost
Poor	25	191	Plant trees, brush, grass 8 miles at $1,500/ mile Rock riprap 17 miles at $30,000/ mile	4,775	$109.32	$522,000
Very poor	11	255	Plant trees, brush, grass 2 miles at $1,500/ mile Rock riprap 9 miles at $50,000/ mile	2,085	161.50	453,000
	36			7,580*		$975,000

*A reduction of 7,580 tons per year of fluvial sediment is 29 percent of the total present sediment load and a 46 percent reduction in the estimated 1970 postburn sediment load increase.

[1]Tons per mile of fluvial sediment reduction required to get below the alternative limit of less than 150 tons per mile per year

[2]Riprap cost based on Corps of Engineer estimate of $10/cubic yard for Class II (2 feet thick) riprap. Revegetation based on 2 5 acres per mile and includes bank shaping.

Alternative 4:

Reduce present fluvial sediment sources in the Entiat Basin to less than 85 tons per mile per year from stream channels. This is about 2½ times the preburn rate.

Remarks:

This alternative is formulated on the premise that the most severely erodible channel reaches in each stability class will be treated.

Channel Stability	Total Miles	Sediment[1] Rate Reduction Tons/Miles/Year	Treatment[2]	Tons of Sediment Reduced	Cost/Tons Sediment Reduced	Total Cost
Fair	35	149	Plant trees, brush, grass 2 miles at $1,500/ mile Rock riprap 15 miles at $25,000/ mile	5,215	$ 77.66	$ 405,000
Poor	25	191	Plant trees, brush, grass 8 miles at $1,500/ mile Rock riprap 17 miles at $30,000/ mile	4,775	109.32	522,000
Very poor	11	255	Plant trees, brush, grass 2 miles at $1,500/ mile Rock riprap 9 miles at $50,000/ mile	2,085	161.50	453,000
	71			12,795*		$1,380,000

*A reduction of 12,795 tons per year of fluvial sediment is 49 percent of the total present sediment load and a 78 percent reduction in the estimated 1970 postburn sediment load increase.

[1]Tons per mile of fluvial sediment reduction required to get below the alternative limit of less than 85 tons per mile per year.

[2]Riprap cost based on Corps of Engineer estimate of $10/cubic yard for Class II (2 feet thick) riprap. Revegetation based on 2.5 acres per mile and includes bank shaping.

Alternative 5:

Reduce present fluvial sediment sources in the Entiat Basin to approximate the 1970 prefire condition — which had an estimated average gross fluvial sediment load of about 10,000 tons per year (<32 tons per mile per year from channels).

Remarks:

This alternative is formulated on the premise that the most severely erodible channel reaches in each stability class will be treated.

Channel Stability	Total Miles	Sediment[1] Rate Reduction Tons/Miles/Year	Treatment[2]	Tons of Sediment Reduced	Cost/Tons Sediment Reduced	Total Cost
Very Fair	34	85	Plant trees, brush, grass 24 miles at $1,500/mile Rock riprap 10 miles at $15,000/mile	2,890	$ 64.36	$ 186,000
Fair	35	149	Plant trees, brush, grass 20 miles at $1,500/mile Rock riprap 15 miles at $25,000/mile	5,206	77.66	405,000
Poor	25	191	Plant trees, brush, grass 8 miles at $1,500/mile Rock riprap 17 miles at $30,000/mile	4,781	109.32	522,000
Very poor	11	255	Plant trees, brush, grass 2 miles at $1,500/mile Rock riprap 9 miles at $50,000/mile	2,085	161.50	453,000
	105			15,682*		$1,566,000

*A reduction of 15,682 tons per year of fluvial sediment is 59 percent of the total present sediment load and a 96 percent reduction in the estimated 1970 postburn sediment load increase.

[1]Tons per mile of fluvial sediment reduction required to get below the alternative limit of less than 32 tons per mile per year.

[2]Riprap cost based on Corps of Engineer estimate of $10/cubic yard for Class II (2 feet thick) riprap. Revegetation based on 2.5 acres per mile and includes bank shaping.

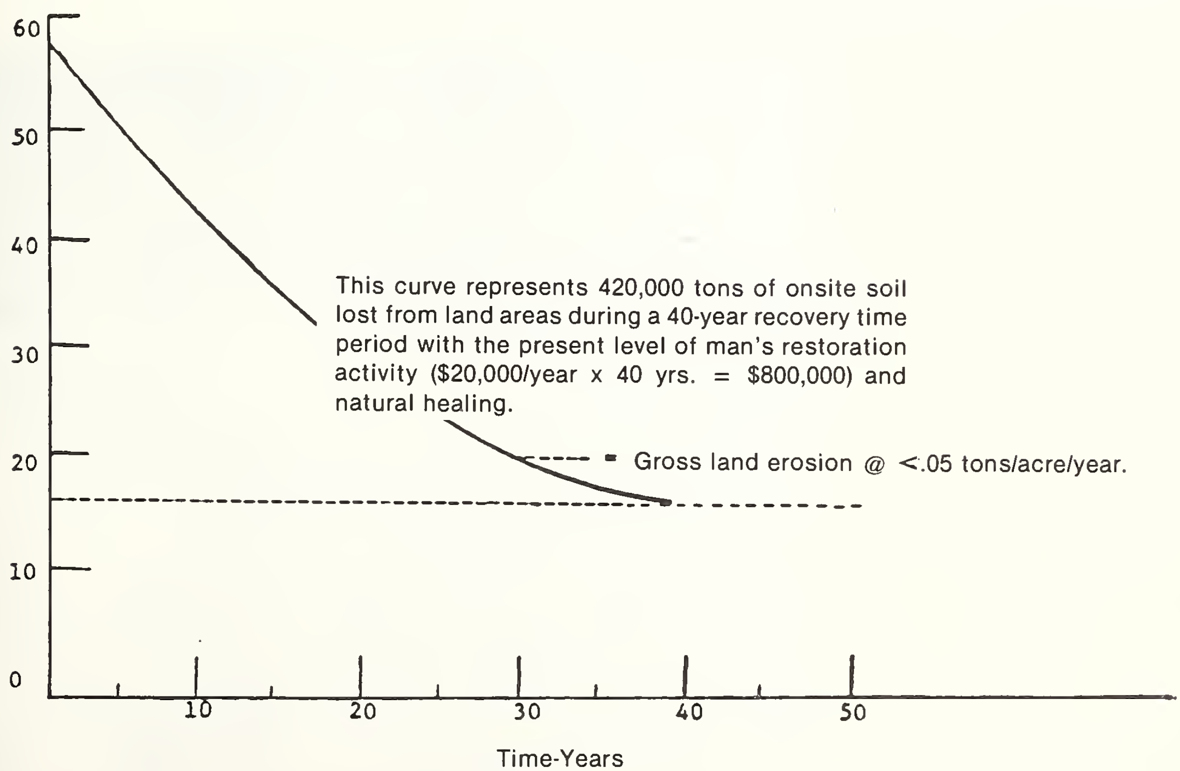
Objective: Erosion Reduction - Land

Alternative 1:

(Without plan) Reduce mean annual land erosion to less than .05 tons per acre per year on all lands except stream channels using current level of funding — about $20,000 per year. This alternative places maximum demand on nature to accomplish the stabilization over time. It estimates the onsite soil loss expected (tons per year) from the Basin during the estimated 40-year healing process.

Remarks:

This alternative is formulated on the premise that the most severely erodible acres in each area will be treated first.



Note: r^2 of this erosion depletion regression curve is estimated to be .85.

Dry creep of pumice soils.

Bedload deposition and streambank scour on far bank.

Alternative 2:

Reduce mean annual and erosion to less than .5 tons per acre per year on all land acres except stream channels.

Remarks:

This alternative is formulated on premise that the most severely erodible acres in each area will be treated.

Map Area	Total Acres	Erosion[2] Rate Reduction	Treatment	Tons Erosion Reduction	Mean Cost/Ton Reduction	Total Cost
Silver	1,547	.15	Plant trees 8x8 on 500 acres grass seed 500 ac. ave. cost $300/ac.	232	$646.55	$150,000
Brennigan	3,330	.08	Reinforce tree planting & road bank stabilization 500 ac. at $200 per acre	266	375.38	100,000
Burns	3,436	.01	Reinforce grass seeding road cuts sheet & gully 100 ac. at $100 per acre	37	272.48	10,000
Fox	937	.26	Seed grass in all stream corridors & plant trees 6x6 on 937 ac. planned cost $250 per acre	244	961.61	234,250
Rangeland[1]	7,484	.25	Fertilize 3,740 ac. at $50 per acre	1,871	100.00	187,000
	16,734 ac.	Tons of erosion reduction possible*		2,650	(257.10)	$681,250
		Tons of fluvial sediment reduction possible*		611.7	(1113.70)	$681,250

*Note: This alternative would reduce gross land erosion by approximately 4.8 percent.
This alternative would reduce gross fluvial sediment by approximately 2.2 percent.

Note: The time estimate for erosion reduction (2,650 tons/year) to occur under this alternative is 5 years following treatment.

[1]Private rangeland in extreme southeast corner of the Basin.

[2]Difference between current mean annual erosion rates (tons per acre per year) and the objective of less than .5 tons/acre/year.

[3]See original

Alternative 3:

Reduce mean annual land erosion to less than .19 tons per acre per year on all land acres except stream channels.

Remarks:

This alternative is formulated on premise that the most severely erodible acres in each area will be treated.

Map Area	Total Acres	Erosion[3] Rate Reduction	Treatment	Tons Erosion Reduction	Mean Cost/Ton Reduction	Total Cost
Red[1]	4,480	.24	Treat red area center of Basin with trees & grass 500 ac. at $200/acre	1,075	$ 93.02	$ 100,000
Orange	54,249	.05	Reveg. roads, plant trees 1,000 ac. Seed 1,000 ac. at $200/acre	2,712	147.49	400,000
Fox	937	.57	Seed grass and fert. 700 ac. at $150/acre Plant trees, 900 ac. at $100/acre	534	365.17	195,000
Silver	1,547	.46	Plant trees, 1,000 ac. at $100/ac. Seed and fertilize 500 ac. at $150/ac.	711	246.13	175,000
Brennigan	3,330	.39	Reveg. & surface roads 50 ac. at $1,000/ac. Plant trees & brush 1,000 acres at $100/acre	1,298	115.56	150,000
Mcree	1,555	.11	Grass seed & fert. 500 acres at $150/ac. Plant trees 500 ac. at $100/ac.	171	730.99	125,000
Burns	3,436	.32	Road reveg. 50 ac. at $1,000/ac. Plant trees 1,000 ac. at $100/ac.	1,099	136.49	150,000
Preston	4,587	.18	Road reveg. 150 ac. at $500/ac. Plant trees 500 ac. at $100/acre	825	151.52	125,000
Range (pvt.)[2]	7,484	.56	Seed & fert. 2,000 ac. at $100/acre	4,191	47.72	200,000
Orchard (pvt.)	1,583	.06	Seed grass 100 ac. at $50/acre	95	52.63	5,000
	83,188 ac.	Tons of erosion reduction possible*		12,711	(127.84)	$1,625,000
		Tons of fluvial sediment reduction possible*		3,026	(537.01)	$1,625,000

*Note: This alternative would reduce gross land erosion by approximately 23.3 percent.
This alternative would reduce gross fluvial sediment by approximately 10.9 percent.

Note: The time estimate for erosion reduction (12,711 tons/year) to occur under this alternative is 10 years following treatment.

[1]Red area in center of Basin only.
[2]Private rangeland in extreme southeast corner of Basin.
[3]Difference between current mean annual erosion rates (tons/acres/year) and the objective of less than .19 tons/acre/year.

Alternative 4:

Reduce mean annual land erosion to less than .1 tons per acre per year on all land acres except stream channels.

Remarks:

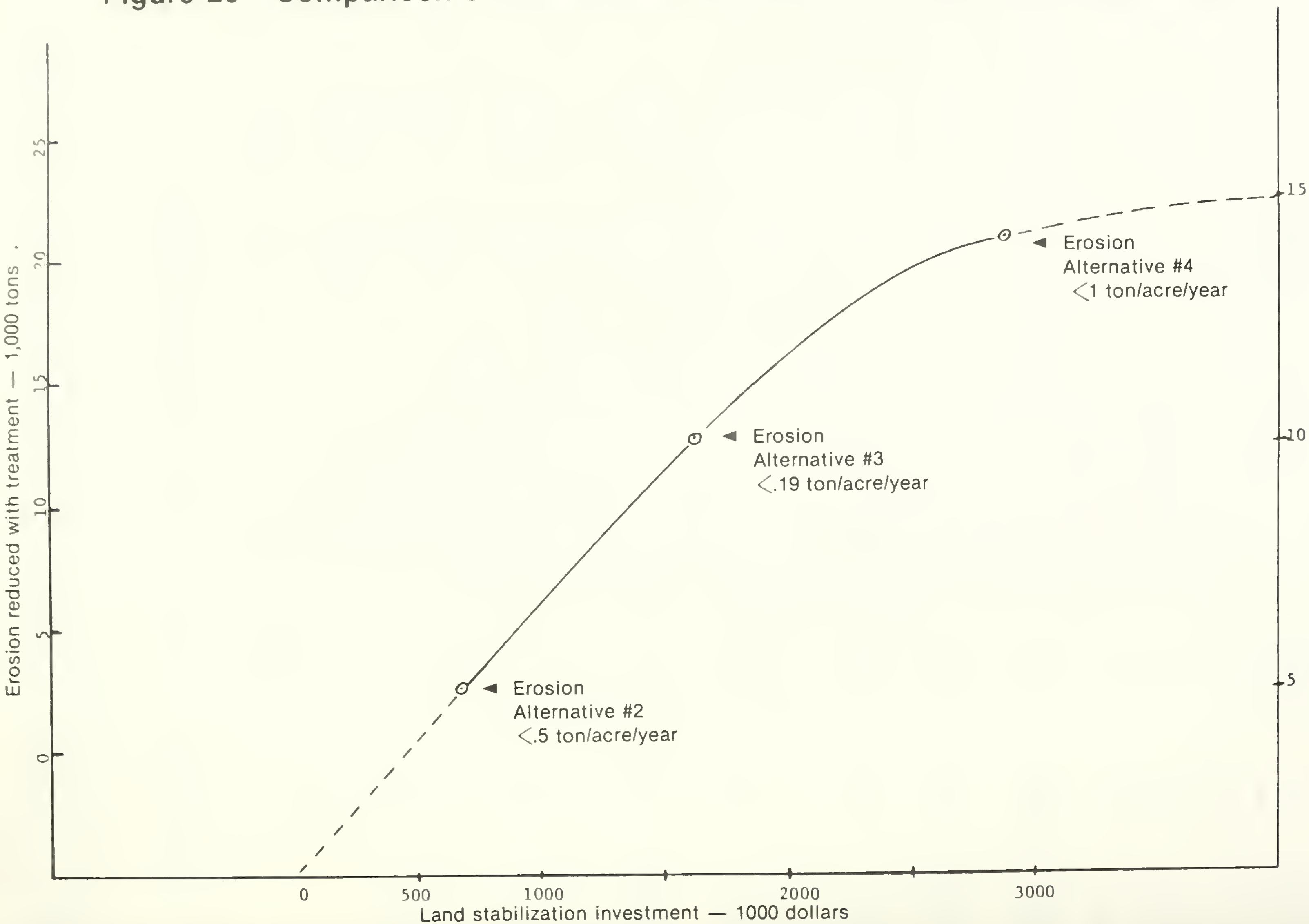
This alternative is formulated on premise that the most severely erodible acres in each area will be treated.

Map Area	Total Acres	Erosion[3] Rate Reduction	Treatment	Tons Erosion Reduction	Mean Cost/Ton Reduction	Total Cost
Brown	9,116	.04	Plant trees 1,000 ac. at $100/ ac. Seed grass 500 ac. at $50/ acre	365	$342.46	$ 125,000
Red[1]	4,480	.33	Plant trees 2,000 ac. at $100/acre & grass 1,000 ac. at $50/ acre	1,478	169.14	250,000
Orange	54,249	.14	Reveg. roads 1,000 ac. at $500/ac. Seed 1,000 ac. at $50/ac. Plant trees 2,000 ac. at $100/acre.	7,595	98.75	750,000
Dk. Blue	21,061	.05	Grass seed & fert. 1,000 ac. at $100/ac. Plant trees 500 ac. at $150/ac.	1,053	166.19	175,000
Fox	937	.66	Seed grass and fert. 700 ac. at $150/ac. Plant trees 900 ac. at $100/ac. Plant shrubs 200 ac. at $200/ac.	618	380.25	235,000
Silver	1,547	.55	Plant trees 1,200 ac. at $100/ac. Seed & fert. 500 ac. at $150/ac. Fell snags 100 ac. at $200/ac.	851	252.64	215,000
Brennigan	3,330	.48	Reveg. roads 100 ac. at $1,000/ac. Plant trees & brush 1,200 ac. at $150/ac.	1,598	175.22	280,000
McCree	1,555	.20	Road reveg. 100 ac. at $1,000/ac. Plant trees 1,000 ac. at $100/ac.	1,409	141.94	200,000
Preston	4,587	.27	Road reveg. 300 ac. at $600/ac. Plant trees 1,000 ac. at $100/ac.	1,239	225.98	280,000
Range (pvt.)[2]	7,484	.56	Seed & fert. 2,000 ac. at $100/ acre	4,191	47.72	200,000
Orchard	1,583	.15	Grass & fert. 100 ac. at $150/ac.	237	62.29	15,000
	104,249 ac.		Tons of erosion reduction possible*	20,945	(137.50)	$2,880,000
			Tons of fluvial sediment reduction possible*	3,730	(772.12)	$2,880,000

*Note: This alternative would reduce gross land erosion by approximately 38.5 percent.
This alternative would reduce gross fluvial sediment by approximately 13.5 percent.

[1]Treat red area in center of Basin only.
[2]Private rangeland in extreme southwest corner of Basin.
[3]Difference between current mean annual erosion rate in tons/acres/year.
[4]Due to the natural ecosystem, it is unfeasible to reduce range erosion less than .19 tons per acre per year.
Note: The time estimate for erosion reduction (20,945 tons/year) to occur under this alternative is 12 years following treatment.

Figure 23—Comparison of Alternatives for an Erosion Reduction Objective



Alternatives Studies to Specifically Address Problems on Agricultural Lands

OBJECTIVE: Reduce Soil Erosion

Nonirrigated Cropland: If these areas are maintained in crop production, soil erosion rates can be reduced by improved management systems. It is estimated that existing soil erosion rates can be reduced by 30-60 percent if stubble mulch tillage systems are used on summer fallow fields.

The present summer fallow wheat rotation of nonirrigated cropland within the Entiat Basin is averaging 0.5 tons per acre loss annually. Thus, the 300 acres, half of which are cropped each year, contribute about 150 tons total per year.

These small plots are not conducive to stripcropping and stubble mulch is doing the job with contour seeding and deep furrow drills.

Rangeland: Good management systems need to be continued on rangeland areas for erosion control. If good vegetative cover is lost, erosion rates will increase. A major hazard to the range resource is from fire and subsequent erosion damage. A dependable and effective fire prevention program must be maintained. Such a program should include: development of adequate access roads, development of fire suppression lanes, and water supply sources. Programs for private rangeland should be coordinated with similar management programs for public rangeland.

Objective: Flood Damage Reduction - Agricultural Lands

Alternative 1: Streambank Protection

Riprapping the streambanks along certain orchard frontage sites will provide erosion protection for some landowners.

Preliminary investigations indicate that 2,950 linear feet of riprap would be needed to protect 200 acres of orchard. One and five tenths acres of orchard has been lost annually.

Potential sites for riprap installations have been identified and quantified. (See Critical Erosion and Rehabilitation Needs Map following page 128).

The orchardland that is being lost annually produces an estimated 650 boxes of apples valued at $2,000.

Riprapping projects are usually installed by individual landowners or small groups of landowners. Present construction costs average $30 per linear foot. Special project cost-sharing programs through the USDA Agricultural Stabilization and Conservation Service may be available to farmers for this practice. The portion of the cost paid by farmers is also eligible for income tax deduction purposes.

Since engineering, project administration and land rights costs may be high, informal group projects may be the most effective way to solve streambank erosion projects.

Alternative 2: Construction of Dikes Against 50- 100-Year Events

Some landowners have built low levees to protect cropland and buildings from floodwaters. These levees are effective against typical high spring runoff. They are not constructed to handle major floods.

Average annual benefits of levee construction have not been determined. However, based on cost estimates, average annual benefits of $37,000 would have to be obtained to justify costs of levee construction.

Preliminary estimates indicate that for 50- and 100-year events, construction of 16,000 feet of levees at various locations along the River would protect 27 acres of orchard, 15 buildings, and the fish hatchery. The estimated cost of this construction is $560,000. The 16,000 feet of levee would cover approximately 160 acres of land, some of which is now planted to orchards. Some of the buildings are of relatively low value, others are family dwellings. First floor elevations of these structures must be determined, potential hazards to lives of people evaluated, and value of the protected property obtained before accurate benefit cost data can be developed. Levee construction may not be justified to protect all lands from flooding, but levees to protect high value facilities such as the fish hatchery may be justified. These and other environmental impacts must be evaluated if more detailed investigations are to be conducted.

Alternative 3: Stream Channel Clearance

The Entiat River channel is restricted at several points with debris bars and bedload deposits. A detailed analysis of costs and benefits of clearance has not been made. However, many of these bars were inventoried and their location is shown on the Critical Rehabilitation Needs Map. Preliminary analysis shows that a stream channel clearance measure would be beneficial in two ways: 1) enlargement of channel capacity would reduce the severity of flood events, and 2) elimination of bars would reduce deflection currents which erode streambanks. Until fluvial sediment sources are stabilized to a significant degree, stream channel clearance is considered to be a temporary improvement.

This alternative was not explored further because the Corps of Engineers currently has authorization which could include this work. The Entiat River channel clearing, rectification, and bank protection project, authorized by the Flood Control Act of 1950, has not been constructed. The Corps of Engineers began a deauthorization study of the Entiat project under authority of Section 12 of the Water Resources Development Act of 1974. This Act requires review of unconstructed projects which may no longer be needed. However, the deauthorization study has been deferred pending completion of this USDA River Basin Study. The Corps of Engineers gives consideration to public concern for bank erosion in their recommendation regarding the 1950 Entiat River Authority.

Wood debris deposited on bar by Crum Canyon flood. Bar itself restricts channel.

Alternatives Studied to Meet Single Purpose Objectives

The following objectives are addressed:

- Protection of Irrigation Systems from Sediment Damage.
- Removal of Sediment from the Entiat Mouth.
- Enhancement of Anadromous Fish Spawning.

It is important to note that the preceding alternatives which meet erosion and sediment reduction objectives provide long-term solution of these problems as well as addressing other Basin needs.

OBJECTIVE: Protection of Irrigation Systems from Sediment Damage

There are five alternative methods which have been considered for removing sediments from irrigation water in the River Basin. These alternatives are: (1) construction of sediment ponds, (2) Rainey Collector System construction, (3) well construction, (4) filters, and (5) no action.

Alternative 1: Sediment Pond Construction

Installation of sediment ponds would remove 80 to 90 percent of the sediments from water before it reaches irrigation systems. (See diagram, Appendix J). The ponds would have to be large enough to detain the water at least 2 hours after it is diverted from the stream to allow sediments to settle out. Water would be taken from the pond surface and pumped into sprinkler systems. Annual cleaning of the ponds would be required. Estimated cost of sediment pond systems construction and maintenance is $4.00/acre/year. Construction permits would be required from Washington State Department of Ecology and the State Game Department.

Alternative 2: Rainey Collector

This system would require construction of buried, horizontal tile lines which would carry irrigation water from the River to a vertical collector. (See diagram, Appendix J). The tile lines would be installed 4 to 6 feet below the bottom of the River. A sand and gravel filter field would be installed around the tile lines. Existing surface water rights would continue in effect with this alternative. The estimated annual cost for construction of this system is $3 per acre. Construction permits from Washington State Department of Ecology and State Department of Game would be required before these systems could be installed. On-site investigation for each system would be required by a qualified engineer and/or geologist.

Alternative 3: Irrigation Wells

Irrigation wells could be constructed to replace existing surface water irrigation systems. For irrigation of a 50-acre field, an 8-inch diameter well approximately 80 feet deep, would be required. The annual cost of this system is estimated at $400 or $8/acre. Additional costs would be incurred in relocation of electric powerlines and pumping systems. Each site would require on-site investigations by a qualified geologist. Permits for use of ground water for irrigation purposes would have to be secured.

Alternative 4: Installation of Sand Filters

Sand filters can be installed in existing irrigation systems to remove sand particles carried in the water which are most damaging to the systems. It is estimated that these filters can be installed at a total cost of $40 per acre irrigated. Estimated filter life is 25 years for an average annual cost of $3.50 per acre.

Use of Rainey Collector systems, or construction of irrigation wells would be the more effective methods of reducing sediment problems in irrigation systems.

Alternative 5: No Action — Cleanout and Annual Repair of Existing Irrigation System

If present irrigation systems are maintained, continued repair and maintenance will be required. Evaluations concluded that costs of maintaining existing systems will exceed normal rates because of high sediment levels in irrigation waters. The estimated annual cost of this repair and maintenance over and above normal levels is estimated at $189,600 per year. If irrigation systems are shut down during peak orchard crop production periods, crop yields will be reduced. Yield reduction costs are estimated at $127,400 annually. Total annual agricultural damages due to sediment are estimated at $317,000.

OBJECTIVE: Removal of Sediment from the Entiat Mouth

Two methods of removal are considered:

(1) Dredge, using a dragline or similar device.

(2) Drawdown of the reservoir to enable a flushing action or the use of equipment in the channel itself

Lake Entiat is not lowered by the Chelan Co. P.U.D. on any set schedule. There are times when the Corps of Engineers may require that the reservoir be drawn down in order to provide for increased storage during heavy runoff. The Chelan Co. P.U.D. is willing to coordinate drawdown when needs are known. This requires long-range planning, flexibility in scheduling, and the ability to accomplish the job within the low water period. The best opportunities for this would be late winter or early spring before runoff.

It is not likely that flushing action alone would remove a significant amount of sediment from the Entiat River. Flushing would have to occur during the River's high flow periods, but because the En-

Table 24.—Summary of Conservation Practices Specifically Intended to Address Problems on Agricultural Lands

Conservation Practice	Unit	Amount	Unit	Total	Administrating Agency(s)
Stubble Mulch Tillage[1]	Ac.	300	$ 25	$ 7,500	SCS, ASCS
Stream Channel Stabilization	Ft.	2950	$ 30	$ 88,500	SCS, ASCS, Army Corps of Engineers
Clearing	Cy.	Not Estimated			Army Corps of Engineers
Protection of Irrigation Systems — Sediment Damages					
Alt. #1 Sediment Ponds	Ac.	1300	$ 40	$ 52,000	SCS, ASCS, Special Programs
Alt. #2 Rainey Collectors	Ac.	1300	$ 30	$ 39,000	SCS, ASCS, Special Programs
Alt. #3 Wells	Ac.	1300	$ 80	$116,000	SCS, ASCS, Special Programs
Alt. #4 Filters	Ac.	1300	$ 40	$ 52,000	SCS, ASCS, Special Programs
Alt. #5 No Action	Ac.	1300	$244	$317,000[2]	Local

[1]In place (see discussion page 114). Not treated separately as an alternative.
[2]Indicates estimated Average Annual Cost of repair and clean-out of sprinkler systems, pumps and irrigation ditches.

tiat mouth is restricted, water tends to back up and flood The ability to achieve a differential here which would facilitate flushing is questionable.

A dragline or similar device permits a greater choice of operating time. It also has the advantage of reclaiming sediment for reuse. There is a demand for such material for use in rejuvenating orchardland and in landscaping building sites. Apparently disposal of the material will be no problem.

Operation of a dragline would be difficult because of the limited area to set a crane and stockpile material. An operator and oiler are required at an estimated cost of $75 per hour. A frontend loader was used earlier by the Corps. This type of machine costs less, $58 per hour, but is more restricted. A 10-yard loader was used successfully at the mouth of Crum Canyon. However, the area at the Entiat mouth remains wet and is a poor operating base even in the fall.

A portable dredge probably is not feasible due to the restricted operating area and the expense of getting one to the site.

The cost of hauling dredge material is estimated to be $0.24 per ton per mile. The Corps of Engineers was able to affect a significant savings at Crum Canyon by having the trucks haul riprap one way and carry dredge material on return. This was possible because of the unique proximity of job, rock source, and spoil site. Such a savings will probably not be possible from the Entiat mouth.

The cost of removal of material will vary with depth. If the channel is deepened, it will be necessary to construct a structure upstream to prevent progressive downcutting. Without such a structure, sediment will immediately begin to refill the channel.

It is important to note that benefits wil be short-lived if rehabilitation of the lower Entiat occurs before upstream sediment sources are controlled. The objective of sediment removal should be clearly defined in order to weigh cost against expected benefits.

OBJECTIVE: Enhancement of Anadromous Fish Spawning

In 1973, the Washington Department of Fisheries cleaned approximately 9,000 square yards of gravel in the vicinity of Brennegan Creek. Although fish showed a definite preference for the cleaned areas, sampling showed the percentage of contaminants (material less than 3.36 mm diameter) was reduced from 35.2 percent to 32.0 percent — a very modest improvement. Based on these results, it is the opinion of fishery experts that gravel cleaning is not a viable rehabilitation alternative for the Entiat River.

Enlargement of the existing artificial spawning channel near Fox Creek appears to be the best short-term enhancement possibility for spring chinook. According to initial engineering reports, the spawning channel could be lengthened to 1,000 to 1,200 feet.

The best long-range program to improve Entiat River fisheries production is, of course, to stabilize the soils in the burn area which will help prevent future flooding and earthslides. Entiat River production potential can be increased by providing access to additional spawning area above Fish-Tail Falls and Entiat Falls. This would require installation of fish ladders at both barriers. Based on surveys conducted on the Mad River, development of this tributary for chinook production does not appear feasible at this time.[17]

Table 2d.—Comparison of Alternatives and Their Effects on Citizen Identified Problems.

	Fluvial Sediment Reduction					Erosion Reduction — Land				Flood Damage Reduction			Single Purpose		
	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 1	Alt. 2	Alt. 3	Alt. 4	1	2	3	1	2	3
Action Sediment— Expected Reduction	OnGoing PreFire cond (50 yr. time)	Veg. RipRap 2,805 Tns.	RipRap Veg. 7,580 Tns.	RipRap Veg. 12,795 Tns.	RipRap Veg. 15,682 Tns.	OnGoing PreFire cond (40 yr. time)	Veg. 612 Tns.	Veg. 3,026 Tns.	Veg. 3,730 Tns.	Riv. Bank Protection Not calc	Const. Dikes	Channel Clearing	Protect Irriga. See Tab.2b	Entiat Mouth See Ch.4	Fish Spawn See Ch.4
Erosion - Expected Reduction							2,650 Tns.	12,711 Tns.	20,945 Tns.	2,950 lin.ft.					
Flood - Expected Reduction Remarks										88,500	50 yr & 100 yr Not feas.	Not estimated		See Discussion Problem Effects Section	
COST	$1,000,000	$453,000	$975,000	$1,380,000	$1,566,000	$800,000	$681,250	$1,625,000	$2,880,000	$88,500	$560,000	Not estimated			
PROBLEM ADDRESSED[1]															
EROSION OF LAND		1	2	3	3		2	4	4	4					
FLOOD OF LAND			1	1	3						4	4			
DEPOSIT OF SEDIMENT		2	3	4	4		1	2	2	2				1	
SED. IN IRRIGATION		2	3	4	4		1	2	2	2			4		
FISHERY DEGRADATION		2	3	4	4		1	2	2	2					2
DRINKING WATER QUAL.		1	2	3	3		1	1	1	1					
PUBLIC SAFETY								2	2						
VISUAL RESOURCE		2	3	4	4		2	2	2	2				1	
RECREATION		1	2	4	4		1	1	1	1				1	

[1]Alternatives' degree of effectiveness in addressing concerns by Citizens Committee

1 - Incidental
2 - Slight
3 - Moderate
4 - High

Chapter 5—Program Selection

This Study has attemped to:

- Quantify Basin problems
- Show problem relationships
- Display a set of alternative solutions that address problems to varying degrees
- Identify priority areas needing treatment

Also discussed are possible sources of agency assistance that may be available for technical assistance, financial assistance, and project planning.

Alternatives for reducing erosion, sedimentation and flooding offer long-range solutions to a wide range of problems. Approximately 72 percent of the fluvial sediment from forested lands in the Entiat River Basin originates in the stream channel system. If the water quality objectives in this Basin are to be accomplished, effort should be concentrated on streambank and lower slope erosion sources.

Also displayed are certain single purpose objectives. For instance, well drilling may solve an irrigation problem but it does nothing to prevent further land loss, sediment deposit and degradation of the fishery.

The chosen program should strike a balance between:

- Long-range solutions
- Providing for immediate needs such as protection of prime orchards
- Short-range solutions such as increased artificial spawning channels

The selected program should also:

- Assure that funds are directed to areas which promise the greatest problem reduction

- Consider social well-being objectives as well as economic ones. Conversely social well-being objectives should be counted as benefits to offset costs

- Be designed to meet a range of objectives established by the Entiat Community

- Recognize the cause and effect interrelationship of problems

- Assure that the objective of any remedial measure is identified so that benefits can be quantified.

The next step

The citizens of the Entiat Valley, working with appropriate agencies, need to establish a community objective and programs to meet their needs.

This report can form the basis for development of specific project plans by private citizens and agencies. It can also be the basis for the formulation of a concerted effort by various individuals and agencies to attack problems on a broad front.

The Land Erosion and Sediment Yield Map and the Stream Channel Stability Map can both be used to direct work to critical areas.

The hydrologic analysis, erosion and sediment yield data can be used to support project plans. They both scope the problem and indicate an expected result from remedial measures in terms of problem reduction.

Following is a discussion of agency programs, existing and potential, which may be a resource in solving Basin problems.

Existing Mechanism for Assistance

Agency Activities

The Soil Conservation Service (SCS) became active in the Entiat River Valley in 1947 when the Wenatchee-Entiat Conservation District was organized. Major SCS activities have included technical assistance to farmers in planning and applying conservation practices on the land. This assistance is available to all farmers and ranchers in the Basin.

Soil surveys have been completed for most of the privately owned lands in the Basin. The survey was done by SCS, in cooperation with the Washington Agricultural Experiment Station and has been published as a part of the Soil Survey of Chelan Area, Washington. The balance has been surveyed by the U.S. Forest Service.

Recently, SCS has been working with conservation districts, the State of Washington Department of Ecology and local water quality committees on county water quality plans. This activity has been accelerated to meet water quality guidelines of the Federal Water Pollution Control Act (P.L.92-500).

SCS assists the Agricultural Stabilization and Conservation Service (ASCS) with the technical aspects of conservation practice cost-sharing programs, including site inspection, layout before practice installation and followup inspection of completed practices. SCS provides technical and financial assistance whenever fire, flood, or other natural disaster causes a sudden impairment of watersheds (Flood Control Act of 1950). As authorized by the Secretary of Agriculture, SCS undertakes measures to retard runoff and prevent soil erosion in order to safeguard lives and property from floods and sedimentation.

SCS provides technical assistance for rehabilitation of land and conservation systems for which the ASCS provides funds for emergency conservation measures as authorized by Public Law 85-58. SCS provides technical assistance for emergency protection against high water and for rehabilitation of rural land by natural disaster.

Conservation Districts Legal subdivisions of state government coordinate soil and water conservation programs within their jurisdictions. The Entiat River Basin is served by the Chelan County Conservation District.

Conservation Districts focus on severe erosion problems. It provides local people, who can work with conservation, plans for implementation. SCS provides a major part of its technical assistance through the Conservation District.

The District also conducts an education program concerning the conservation needs of the area. Effects of these efforts have not been readily apparent under past voluntary programs. Now, their broad impact is being recognized as the District cooperates in development of county water quality plans.

In the future, the District should play an even stronger role in Basin conservation activities. Under the direction of the Resources Conservation Act, the District will assist the Soil Conservation Service in developing a long-range program for conserving the Nation's soil and water resources. This will start with an appraisal of the District's resource problems, opportunities and needs. From this will be developed a local and National program to guide future activities of the Districts, the SCS and other conservation efforts of USDA. Recent State and National laws have given the Conservation District greater authority and responsibility. The Federal Water Pollution Control Act has played a major role in strengthening the mission of Districts. As they work to meet guidelines of this Act, they find people increasingly motivated to use assistance they can provide. As Best Management Practices are applied to the land, District leaders believe the public can continue to seek leadership from their local conservation District. Effective incentives will be needed to stimulate conservation awareness. Districts are arousing concern about keeping water quality planning for nonpoint pollution control at the local level. As the energy crisis intensifies, Districts will be more involved in informing the public of resource problems and the need to solve them through conservation measures.

The Washington State Conservation Commission is an **agency** of State Government which administers the legal and program activities of the 52 conservation districts located in Washington's 39 counties. Its function is described under Chapter 89.08 RCW. The Conservation Commission is housed in and attached to the Department of Ecology (DOE) for administrative and fiscal purposes. Its program operation is independent and is guided with policy developed by the Conservation Commission.

The following list of activities illustrate the Conservation Commission's role relative to other conservation agencies:

1. The Conservation Commission has contracted with the DOE to develop an implemental plan for water quality improvement in dryland agriculture.

2. The Commission has personnel in the field to assist individual conservation districts in program development, specific problems, and specific projects related to natural renewable resources.

3. The Commission sponsors and conducts training conferences, e.g.:

   a. To acquaint conservation district supervisors with duties, responsibilities, and opportunities.

   b. To explain and implement uniform accounting procedures with conservation districts.

   c. To give motivational training.

4. The Commission is responsible for seeing that supervisor elections are conducted and appoints two of the local five-member board of supervisors in each district.

5. The Commission conducts regular meetings throughout the State, focused on understanding the complex problems and opportunities of Washington's natural renewable resources. Periodic commission/conservation district board interaction around the State is carried out to allow a better mutual understanding of priority resource problems and opportunities.

6. The Commission develops job descriptions, recruitment, and training programs for district employees.

7. The Commission interacts and coordinates programs with the Federal and State natural resource agencies.

Department of Ecology, State of Washington (DOE) is responsible for planning, management and regulation of water and related land resources of the State. DOE coordinates Federal and State grants for planning construction. Floodwater damage, shoreline management, coastal zone management, water quality and water rights are among their resource management responsibilities.

DOE has played a major role in initiating action, obtaining funds, and giving coordination and leadership for water quality planning in the state of Washington. They work through the State Conservation Commission and with local conservation districts for water quality committees on development of Best Management Practices to meet National Water Quality Guidelines. They are expected to continue playing a significant role as Best Management Practices are applied to land in Chelan County and the State of Washington.

The Farmers Home Administration (FmHA) makes water development and soil conservation loans to eligible individual farmers, rural residents, groups of farmers and rural communities. These loans are for developing water supply systems for domestic, livestock, and irrigation use, and for carrying out soil conservation practices. Each loan is scheduled for repayment according to the borrower's ability to repay, over a period of not more than 40 years. Loans also are made to local organizations to help finance projects and develop land and water resources in watersheds planned under authority of Public Law 83-566. Eligible local organizations include flood control districts, irrigation districts, drainage districts, and similar legal entities which have authority under state law to construct, maintain, and operate works of improvement. These watershed loans are repayable over periods up to 50 years.

The major purposes of FmHA's rural credit programs are:

1. To help build the family farm system, the

economic and social base of many rural communities.

2. To expand business and industry, increase income and employment, and control or abate pollution.

3. To install water and waste disposal systems and other community facilities that will help rural areas upgrade the quality of living and promote economic development and growth.

4. To provide or improve modest homes in suitable rural environments at prices and on terms that families of low or moderate incomes can afford.

Science Education Administration Cooperative Extension (CE) has long been active in reduction of sediment and erosion. Local county extension agents assisted local farmers in formation of conservation districts under State enabling acts which were passed in Washington in the late 1930's. After districts organized, county agents were involved in arrangements for election of district supervisors, formulation of district programs and work plans, arranging annual district meetings and assisting in district information and education activities.

Recent Federal legislation related to Public Law 92-500 gave the CE a major role in erosion and sedimentation control by cooperating with conservation districts in nonpoint pollution control programs. The CE, through local agents, is cooperating with the SCS in assisting with Section 208 of Public Law 92-500. CE helps organize public awareness programs in counties as well as in formation of county water quality committees. These water quality committees were organized to encourage citizen input into county plans for reducing and eventually controlling nonpoint pollution.

Economics, Statistics and Cooperatives Service (ESCS) conducts National and regional research, planning, and technical consultation. Other ESCS services relate to economic and institutional factors and policy on use, conservation, development, management, and control of natural resources. This includes determining the extent, geographic distribution, productivity, quality, and contribution of natural resources to regional and National economic activity and growth. ESCS also studies resource requirements, development potentials, and resource investment economics; impacts of technology and economics on use of natural resources; resource income distribution and evaluation; and recreational use of resources. The agency also participates in departmental and interagency efforts to formulate policies, plans, and programs for the use, preservation, and development of natural resources.

Agricultural Stabilization and Conservation Service (ASCS). The Agricultural Stabilization and Conservation Service, through its Agricultural Conservation Program, provides cost sharing to landowners and operators for carrying out selected conservation practices on agricultural land. This authority can be used to provide streambank protection. The cost-sharing program is available to individual farmers and ranchers, as well as to groups of landowners who have common problems too large or complex to be handled individually. For each program year, the total of all cost-shares to any person not carried under pooling agreements shall not exceed the sum of $3,500. Where groups of landowners have a common problem, preventive measures may be carried out under a pooling agreement not to exceed the sum of $10,000 per person.

Housing and Urban Development (HUD) awards "block" grants to local governments to fund a wide range of community development activities. These activities include Urban Renewal, Neighborhood Development Grants, Model Cities, Water and Sewer Grants, Neighborhood Facilities Grants, Public Facilities Loans, Rehabilitation Loans, and Open Space Urban Beautification and Historic Preservation Grants.

HUD provides grants for local government comprehensive planning activities, home mortgage insurance, homeownership assistance for low and moderate income families, rental and cooperative housing assistance for lower income families, housing loans for the elderly or handicapped, and mortgage insurance and temporary housing for families in major disaster areas.

They assist in community economic development programs, development of new communities, fair housing and equal opportunity activities, and Federal Insurance Administration. Included in Federal Insurance Administration programs are Federal Crime Insurance, National Flood Insurance and Federal Riot Reinsurance.

HUD provides assistance to state and local governments and individuals affected by natural disasters. They provide Federal aid, encouraging state and local governments to prepare for or prevent natural disasters.

In the Entiat River Basin, HUD has recently been involved in flood insurance studies and natural disaster assistance.

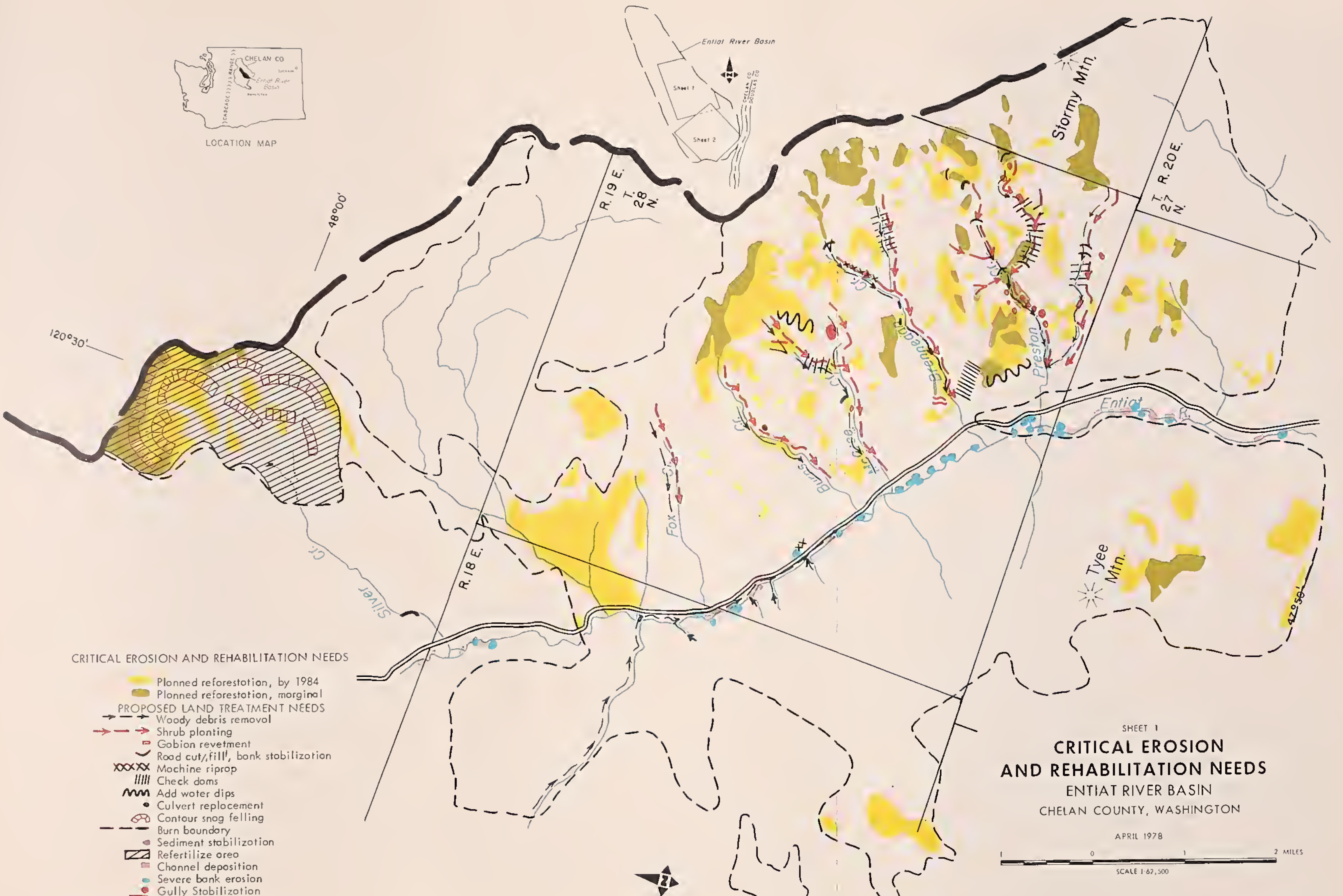
Corps of Engineers (COE). The Flood Control Act of 1950 provides authorization for unspecified protective works and channel clearing on the Entiat River. Project authorization is subject to further study by the Chief of Engineers to establish economic justification prior to construction and local cooperation as specified in the Flood control Act of 1936, as amended.

Emergency bank protection provided by Section 14 of the 1946 Flood Control Act, authorizes the Corps of Engineers to construct, repair, restore, and modify emergency streambank and shoreline protection work to prevent damage to highways, bridge approaches, and public works, and churches, hospitals, schools, and other nonprofit public services. This authority also requires that each project provide benefits equal to or in excess of costs.

Technical and engineering assistance on streambank erosion is authorized by Section 55 of the 1974 Water Resources Development Act. The Act authorizes the Secretary of the Army, acting through the Chief of Engineers, to provide technical and engineering assistance to non-Federal public interest in developing structural and nonstructural methods of preventing damage attributable to shore and streambank erosion.

New Opportunities for Assistance

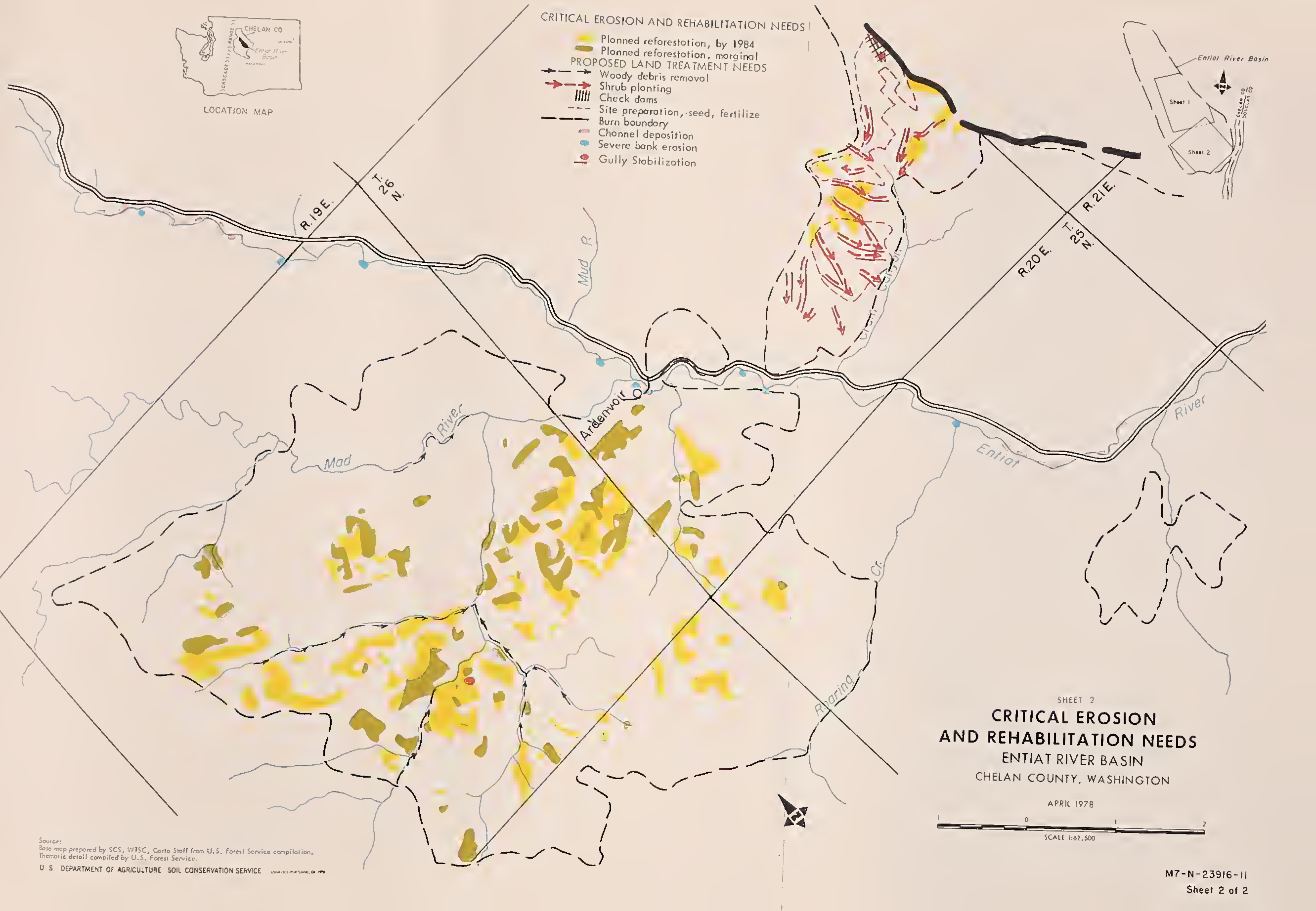
U.S. Forest Service. Much of the work required to reduce erosion and sediment and restore vegetation is centered on National Forest lands. Appendix F itemizes critical needs which the Entiat District has inventoried. These are shown on the Critical Erosion and Rehabilitation Needs Map. Present funding levels to accomplish these are reflected in the Erosion and Sediment, Without Plan Alternatives, Chapter 4. It is also discussed in Projections and Assumptions, Chapter 2. Funding requirements to meet other alternative levels are significant. Because competition between National Forest programs for limited funds is already high, there is probably no realistic effective way to shift existing funds to meet these needs. Therefore, an increased budget request seems appropriate. The plan, assuming one of the accelerated alternatives is to be implemented, should be the basis for estimating this increase. The important thing to stress is that this should not be a shifting of priorities, but a concerted effort to secure additional funding as an "add-on" above the on-going program.



Source:
Base map prepared by SCS, WTSC, Carto Staff from U.S. Forest Service compilation.
Thematic detail compiled by U.S. Forest Service.

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE

M7-N-23916-11
Sheet 1 of 2



CRITICAL EROSION AND REHABILITATION NEEDS
Planned reforestation, by 1984
Planned reforestation, marginal
PROPOSED LAND TREATMENT NEEDS
Woody debris removal
Shrub planting
Check dams
Site preparation, seed, fertilize
Burn boundary
Channel deposition
Severe bank erosion
Gully Stabilization
CHELAN CO
LOCATION MAP
Entiat River Basin
Sheet 1
Sheet 2
R.19E.
T. 26 N.
R.20E.
R.21E.
T. 25 N.
Mud R.
Mad River
Ardenvoir
Entiat River
Roaring Cr.
SHEET 2
CRITICAL EROSION
AND REHABILITATION NEEDS
ENTIAT RIVER BASIN
CHELAN COUNTY, WASHINGTON
APRIL 1978
1 0 1 2
SCALE 1:62,500
Source:
Base map prepared by SCS, WTSC, Carto Staff from U.S. Forest Service compilation.
Thematic detail compiled by U.S. Forest Service.
U S DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE
M7-N-23916-11
Sheet 2 of 2

Soil Conservation Service. Following are two USDA programs which may be implementable if the Basin and project meet critia requirements. It appears that the Entiat Basin would qualify for both the Small Watersheds (P.L. 566) and Resource Conservation and Development (RC&D) Programs. However, whether or not inclusion of the area in one of these programs would improve funding opportunities is problematical. The P.L. 566 Program has many competing projects. Existing operational RC&D Programs have had a backlog of funding needs for several years and new RC&D Areas have not been encouraged. Nevertheless, they should be examined when a community program is developed.

Small Watershed Project (P.L. 566) may have potential for solution of some Basin problems. P.L. 566 projects may include stream channel stabilization and improvement activities, irrigation system rehabilitation or installation of land treatment measures in small watersheds in the Basin. Land treatment measures could include installation of diversions, grassed waterways, debris basins, and grade stabilization structures.

Installation of additional conservation measures could have a significant effect on erosion, sedimentation and water quality in the Basin. Presently, many conservation practices are applied on a piecemeal basis. If an overall plan could be developed over a large area, a more orderly, integrated and efficient system could be installed.

Under the P.L. 566 Program, combinations of measures would be analyzed. Then a proposed project would be selected by local project sponsors. Through the Small Watershed Program, the Federal Government gives technical assistance in planning and installing the project measures, pays the full cost of building flood control measures, and shares in the cost of other measures.

Resource Conservation and Development Projects (RC&D) may hold potential for solution of Basin problems. The area is not now included within a RC&D Project area. However, it is adjacent to the operatinal Yakima-Kittitas RC&D Area. The purpose of RC&D is to speed up resource programs in multiple-county areas as a base for economic development and environmental protection. If the area were included in an authorized RC&D project area (Public law 703, 87th Cong.), SCS would help local sponsors coordinate assistance of other Federal and state agencies in meeting project objectives.

Each RC&D project has its own unique goals, but most aim to:

1. Develop land and water resources for agricultural, municipal, or industrial use and for recreation and wildlife.
2. Provide soil and water resource information for a variety of land and water uses including farming, ranching, recreation, housing, industry, and transportation.
3. Provide conservation measures for watershed protection and flood prevention.
4. Accelerate the soil survey where it complements project measures.
5. Reduce polution of air and water.
6. Speed up conservation work on public land and on individual farms, ranches, and other private holdings.
7. Make needed adjustments in land use by converting surplus or poorly suited cropland to a more beneficial use — grass, trees, wildlife habitat, recreation.
8. Improve and expand recreation facilities; promote historical and scenic attractions.
9. Encourage existing industries to expand and new ones to locate in the area and thus create jobs; encourage industries to process products of the area.
10. Improve markets for crops, livestock, and forest products.
11. Improve or bring to the area needed community facilities such as hospitals, schools, sewage treatment plants, and roads.
12. Encourage training programs to improve job skills. RC&D projects are multicounty in size. Each area is large enough for adequate development of natural resources but small enough for effective local leadership in preparing and carrying out a project plan.

People apply for an RC&D project through local sponsors — conservation districts, county governing bodies, towns, local or state agencies, irrigation districts, public development corporation, and others. If the application is approved by the Governor, it is submitted to USDA. If planning assistance is authorized, SCS names a project coordinator to help the sponsors review the problems and opportunities and develop a plan of action. If the plan is approved, USDA provides technical and financial help in carrying out measures called for in the plan.

Corps of Engineers. In 1950, Congress included 1948 Flood Notes in an Omnibus Bill. The Notes indicated several thousand feet of riprap were needed downstream from Ardenvoir. The Entiat River Channel Clearing, Rectification and Bank Protection Project, authorized by the Flood Control Act of 1950, has not been constructed. Section 12 of the 1974 Water Resources Development Act requires review of unconstructed projects to determine whether the project should be deauthorized. The Corps issued notice of such review in March 1976, but then postponed a deauthorization study pending completion of the USDA Report. The authority obtained by the Corps in 1950 has rarely been used. It would require a Corps of Engineers study to determine project detail. Under this authority Congress does not require projects to be economically feasible.

Continuing Assistance

USDA has a commitment through ongoing programs to continue assistance to the Study cooperators. Such assistance will include:

- Participation with individuals, groups and organizations in utilizing this USDA report to form an Entiat Community Program.

- Analysis and selection of USDA programs to provide technical and financial assistance.

- Technical and financial assistance through on-going programs.

- Continued monitoring of water quality which may be used to evaluate Basin rehabilitation.

- The sharing of technology, developed by the Hydrology Laboratory and Entiat Experimental Forest which may result in an improved rehabilitation program.

Literature Cited

(1) Crum Canyon Flood Rehabilitation Report, Gran Rhodus, Watershed Specialist, USFS, Sept. 8, 1977.

(2) Soil Management Report, Entiat Area, PNW Region, USFS, Iritani, Snyder, Meyer.

(3) Washington's Five Volcanoes, Quiet but not Extinct, Delphine Haley in Pacific Search.

(4) Columbia-North Pacific Comprehensive Framework Study, Appendix V, Vol. 1, Water Resources.

(5) Range Management Plan, Potato Creek C&H Allotment, USFS, 1976.

(6) Mad River Stream Survey—Wenatchee National Forest, Holtby.

(7) Washington State Game Fisheries Report, Richard Allen.

(8) Washington State Game Department, Correspondence, June 23, 1975, Eldred.

(9) Soil Survey of Chelan Area, Washington, USDA, SCS in cooperation with Washington Agricultural Experiment Station.

(10) Development of Vegetation after Fire, Seeding and Fertilization on the Entiat Experimental Forest, Tiedemann and Klock.

(11) US Department of Labor, Manpower Administration, "Summary Manpower Indicators for Entiat Division," 1975.

(12) Census of Population, 1970.

(13) USFS and SCS, USDA field data for soil association.

(14) Study conducted on the Starkey Experimental Range, George Garrison.

(15) Regression developed by W. Knapp, R-6 Silviculturalist, based on PNW 209, Barrett.

(16) Stream Reach Inventory and Channel Stability Evaluation, USFS, Region 1, April 1975.

(17) Conversation with Jim Pope, Recreation Planner, Chelan County PUD, April 12, 1978.

(18) Washington State Department of Fisheries, correspondence, October 17, 1977, Gordon Sandison, Director.

(19) USDI, US Fish and Wildlife Service, correspondence, August 16, 1977, J.R. Blum, Area Manager.

(20) Partial Net Economic Values for Salmon and Steelhead for the Columbia River System, National Marine Fisheries Service, Tuttle, Richards, Wahle, July 1974.

(21) Conversation with Ivan Lines, Biologist, Washington State Office, SCS.

(22) Conversation with Don Oliver, Director, Chelan County Department of Environmental Services, October 9, 1975.

(23) Geomorphology in Environmental Management, Cooke and Dornkamp, 1976, pp. 109.

(24) Conversation with Henry Maekawa, Landscape Architect, Wenatchee National Forest.

(25) Hydrologic Analysis for Forested Lands, Entiat River Basin, State of Washington, Clifford R. Benoit, Hydrologist, Area Planning and Development, USFS, Portland, Oregon 97208, June 1978.

(26) Climate and Hydrology of the Entiat Experimental Forest Watersheds Under Virgin Forest Cover, Helvey, Fowler, Klock, Tiedemann, PNW-42, 1976.

References

Berndt, H.W.
1971. Early effects of forest fire on streamflow characteristics. USDA Forest Serv. Res. Note PNW-148. 9 pp.

Daubenmire, R., and Jean B. Daubenmire.
1968. Forest vegetation of eastern Washington and northern Idaho. Tech. Bull. 60, 104 p., illus. Wash. Agric. Exp. Stn., Wash. State Univ., Pullman.

Flood Information Study, Chelan County, Washington.
1974. R.W. Beck and Assoc.

Grier, C.C.
1975. Effects of fire on the movement and distribution of elements within a forest ecosystem. Unpublished Ph.D. dissertation. Univ. Wash. 167 pp.

Helvey, J.D.
1972. First-year effects of wildfire on water yield and stream temperature in north-central Washington. In National Symposium on Watersheds in Transition. p. 308-312.

Helvey, J.D.
1974. Watershed behavior after forest fire in Washington. Proceedings ASCE Conference on Irrigation and Drainage. Fort Collins, CO. p. 403-422.

Helvey, J.D., A.R. Tiedemann, and W.B. Fowler
1976. Some climatic and hydrologic effects of wildfire in Washington State. Reprinted from Proceedings Annual Tall Timber Fire Ecology Conference, No. 15. USFS.

Klock, G.O.
1971. Streamflow nitrogen loss following forest erosion control fertilization. USDA Forest Serv. Res. Note PNW-169. 9 pp.

Mackin, J.H., and A.S. Cary
1965. Origin of Cascade Landscapes. Washington Divison of Mines and Geology. Information Circular No. 41.

McKee, B.
1972. Cascadia, The Geologic Evaluation of the Pacific Northwest. McGraw-Hill, Inc.

Rich, L.R.
1972. Managing a ponderosa pine forest to increase water yield. Water Resources Res. 8(2):422-428.

Thornbury, W.D.
1969. Principles of Geomorphology. John Niley and Sons.

U.S.G.S.
19 Surface water records of the U.S., Oct. 1950-Sept. 1960. Part 12, Geologic Survey Water Supply Paper 1736.

U.S.G.S
19 Surface water records of the U.S., 1961-1965. Part 12, Geologic Survey Water Supply Paper 1933.

U.S.G.S
19 Surface water records of the U.S., 1966-1970. Part 12, Geologic Survey Water supply Paper 2133.

Wang, J.Y.
1971 Agricultural meteorology. Agricultural Weather Information Service, San Jose, CA. 693 p., illus.

APPENDIX

Appendix A
Public Involvement

A. Public Involvement

Twenty-two representatives of various Federal, State, and citizen groups met March 5, 1975 in Wenatchee at the invitation of the Forest Service to review watershed problems resulting from the major 1970 forest fires and subsequent flooding. George Sorrell, an Entiat Valley resident who is active in the Grange and Kiwanis as well as the orchard business, outlined the problems and costs local orchardists were encountering. Entiat Chamber of Commerce Vice President, Ray Sandidge, stated that Entiat residents were interested in finding out what agencies to seek assistance from if citizens wished to embark on a "self help" program. This emphasis on the local residents' desire to participate in planning and carrying out rehabilitation work led to a second meeting.

The Washington State Department of Ecology sponsored the second meeting April 24, 1975 at Entiat. A letter was mailed to Entiat residents. More than 80 attended this meeting. Following presentations, those in attendance divided into groups. The product of this meeting was the Problem Chart Appendix B which formed the basis of this Study's objectives.

Also, as a result of these initial meetings, a citizens' core group was established. The purpose of this group was to act as a steering committee and sounding board representative of a cross section of those affected by the Entiat problems. G. A. Bremmer, Charles R. Sandidge, and George Sorrell, all involved from the outset, were chosen for this Committee.

This Committee reviewed the USDA Plan-of-Work and met periodically with those collecting data for the Study. Mr. Bremmer arranged for a presentation of the Plan-of-Work to the Chelan County Conservation District, Board of Supervisor's meeting August 6, 1975.

The Committee was also involved with study team members, Entiat District personnel, and others at a meeting October 8, 1975 which actually kicked off the Study.

Study team members met with the Committee, Mike Mulvaney, John Finton, and J.K. McArthur in October 1976. The major product of this meeting was a quantification of irrigation problems.

On December 6, 1977, the study team again met with the Chelan County Conservation District to make a study status report and to present plan formulation concepts for comment.

With presentation of a draft report, citizens involvement will become increasingly important. Data gathering and analysis are complete. Alternatives must now be reviewed, and the Entiat citizens and resource managers must select the course they will follow. The Forest Service has a commitment to assist in this process and to facilitate USDA assistance in project implementation once they are developed.

Appendix B
Problem Charts

B. Entiat River Basin Problem Chart

UPSTREAM PROBLEMS:	Work in Progress or Completed:	Remaining Problems:	Possible Short Term Solutions:	Possible Long Term Solutions:	Alternative Solutions:	Ass't. Agency:	Action Required:
1. Channel stabilization	Channel cleanout Check dams installed	Continued stabilization	1. Drain excess water in slide areas.	1. Plant bare-root shrubs in slide areas. 2. Natural recovery		USFS	
2. Large revegatation program	Seeding and refertilization	Continued revegetation	1.Continue revegetation program	1. Continue revegetation program. 2. Natural recovery		USFS	
3. Reforestation	Seeding and Planting	Continued seeding and planting	1. Continue reforestation program	1. Continue reforestation program. 2. Natural reforestation		USFS	
4. Establish plant life on cut banks	Research with bare root shrubs	Same	Same	Same		USFS	
5. Channel scouring and slumping		Same	No short term solution	1. Revegetation of channel area		USFS	
6. Control of stream channel wandering		Same	No short term solution	1. Vegetative stabilization. 2. Total stabiliz'n upstream		USFS	
7. Identify danger areas for development on alluvial fans	Flood Plain Identification study DNR-Identification of Natural hazard areas. Citizen's group formed Implementation of Shorlines Act. HUD-National Flood Information studies.	Control of development on alluvial fans	1. Land use regulations. 2. Identification of hazard areas. 3. Implement Shorelines Act. 4. Complete flood information studies	1. Public acquisition of lands 2. Continue on-going programs		Chelan County Regional Planning Office & USFS	

Continued

UPSTREAM PROBLEMS:	Work in Progress or Completed:	Remaining Problems:	Possible Short Term Solutions:	Possible Long Term Solutions	Alternative Solutions:	Ass't. Agency:	Action Required:
8. Mass land movement	None	Same	1. Drainage of slump areas	1. Artificial & natural revegetation		USFS	
9. Channel debris and snags	Removal	Same	1. Removal			USFS & Corps of Eng.	
10. OTHER PROBLEMS:							

DOWNSTREAM PROBLEMS:	Work in Progress or Completed:	Remaining Problems:	Possible Short Term Solutions:	Possible Long Term Solutions:	Alternative Solutions:	Asst. Agency	Action Required:
1. River bank erosion	Diking, ripraping, Channelization Snag pulling	Continued erosion of banks	1. Diking 2. Deflectors of current 3. Coordinated efforts by landowners	1. Public Law 566 Small Watershed Act		SCS	
2. Deposit of silt at mouth of Entiat R.	None	Continued silting	1. Lower Lake Entiat and flush out silt.	1. Clean out silt—only if stabilized upstream		PUD	
3. Silt in irrigation systems	Individual farmer effort	Continued silting	1. Settling basins (not entirely effective to remove silt).	1. Research on multiple sumpe 2. Suspend in-take system 3. Private self-help efforts			

Continued

DOWNSTREAM PROBLEMS	Work In Progress or Completed:	Remaining Problems:	Possible Short Term Solutions:	Possible Long Term Solutions:	Alternative Solutions:	Ass't. Agency:	Action Required:
4. Degradation of Fish & Wildlife habitat Loss of spawning beds	Dept. of Fisheries riffle sifting	Stop loss of spawnings beds and habitat	1. Clean gravel 2. Riffle sifting 3. Current training & diversions 4. Reactivate Entiat fish hatchery 5. New habitat	1. Stabilization of vegetation 2. Fish planting program 3. Game ranges		Dept. of Fisheries PUD	
5. Drinking wter quality	None	Improve quality of domestic supply	1. Relocate system	1. Upstream solutions		Dept. of Social & Health Services	
6. Public safety	Development of Flood Forecast Plan	Better communication among agencies & citizens	1. Implement USFS Plan			USFS & Dept. of Emg. Serv.	
7. Damage to structures: roads, homes bridges, etc.	Maintenance program Bank protection along county roads	Continued protection along county roads	Same	1. Relocation of homes & structures out of flood plain.		County Road Dept. & Corps of Engineers	
8. Major economic & aesthetic impact	Self help Economic impact study by UofW and USFS	Quantify impact in economic terms	1. Prepare economic impact assessment			Local citizens organizations USFS	
9. OTHER PROBLEMS:							

Appendix C
Hydrologic Methodology

C. Hydrologic Methodology

This Study began with a review of available literature and data. The study area contains a U.S. Forest Service research hydrology laboratory located in the more disturbed portions of the Basin where water yield and quality data were colleted before and after the 1970 fires. The research subwatersheds consist of Fox, McCree, and Burns. Fox Creek is of tremendous value since it was used as a control following burn restoration and rehabilitation efforts. Although presently a high sediment producer, it serves to illustrate and quantify the benefits of past restoration efforts.

The U.S. Geological Survey maintains a stream gaging station on the main Entiat River and has also sampled sediment. Another data source has been the U.S. Forest Service Barometer Watershed Project which is concerned with monitoring water yield, quality, and timing. Similarly, several bridge stream crossings exist on the river system which facilitated additional streamflow and sediment data collection to fill in the prestudy data voids.

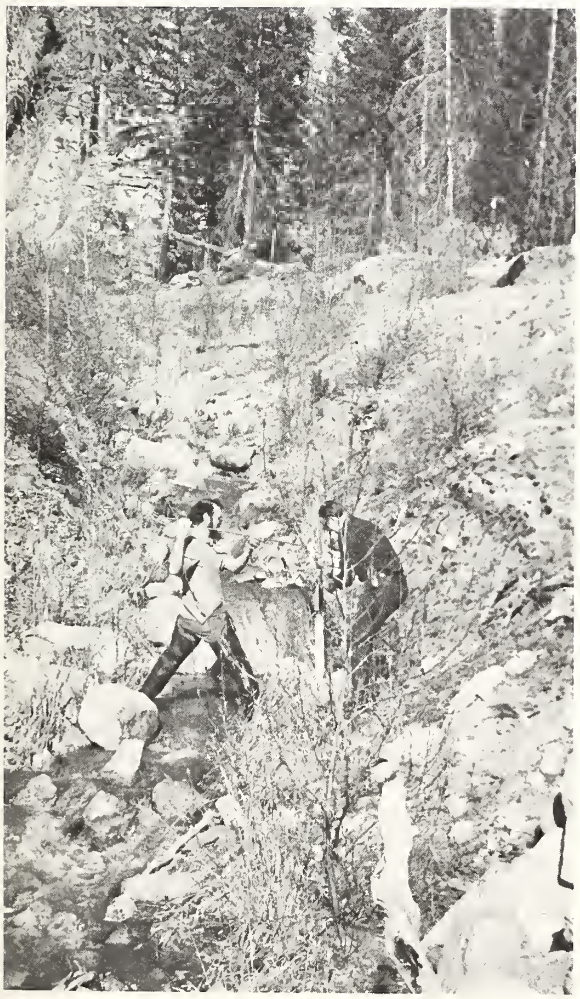
A 1" = 1 mile black and white mosaic using existing 1975 aerial photographs of the study areas was developed. This photography was supplemented by low elevation positive color aerial obliques of the severe disturbance areas. Black and white video tapes of the Entiat River, tributaries, and concentrated disturbance areas were taken from an Alouette helicopter under the direction of Gran Rhodus, Forest Watershed Specialist.

An inventory of existing data, land disturbance, land types, access, and field checks was the basis for dividing the forest lands into 12 subareas to receive intensive erosion and fluvial sediment monitoring. The following equipment was used: Price AA streamflow meter, DH 48 and D 59 depth integrated sediment samplers, Hellie Smith bedload sampler, laboratory sediment analysis equipment, and a Hach 2100A turbidimeter. The regressions between streamflow (cfs) and fluvial sediment (tons/day) used a least squares computer program available at the U.S. Forest Service research hydrology laboratory in Wenatchee. This laboratory equipment was also used to analyze sediment samples.

The sediment samples and concurrent streamflow were collected during the full range of streamflow conditions. In order to arrive at mean annual sediment production, the long-term U.S. Geological Survey stream gaging station data was used to develop 10-year mean annual streamflow hydrographs for the 12 subbasins. This adjusted flow hydrograph data was applied to the flow/sediment regressions in 5-day increments to determine mean annual sediment production. It is important to emphasize that this report discusses projected long-term mean annual erosion and sediment production under *present* land disturbance conditions. For example, it does not account for the sediment production which would result from 200 percent above normal snowpack.

The majority of stream channel was inventoried by field survey, supplemented by aerial photography, and helicoptor-fixed wing aircraft surveys. A system developed by U.S. Forest Service hydrologists based on a quantification of 15 indicators was used. This system is described in a U.S. Forest Service Region 1 publication entitled *Stream Reach Inventory and Channel Stability Evaluation*. The relationship between stream stability point score and mean annual stream channel erosion in tons per mile per year was derived from a regression included in this report. The regression is based on lateral channel migration field survey data. The average sediment delivery rate applied to stream erosion is 85 percent. This percent was developed from stream segment deposition rates based on measured comparative sediment transport rates.

The intensive soil survey by D. Y. Iritani dated 1966 was the basic document used to develop potential surface erosion and hydrologic response to runoff units.



Hydrologists collect sediment sample from a burned out tributary of the Entiat River using a hand held depth integrated sediment sampler. Note staff gage for stream flow correlation.

STREAMSIDE MANAGEMENT RISK
Perennial Streams Only

Low Risk	-	72.0 mi.
Moderate Risk	-	132.5 mi.
High Risk	-	36.5 mi.
Total		241.0 mi.

STREAMSIDE MANAGEMENT UNIT

ENTIAT RIVER BASIN

CHELAN COUNTY, WASHINGTON

APRIL 1978

1 0 1 2 3 MILES
SCALE 1:200,000

Source:
Base map prepared by SCS, WTSC Carto Staff from U.S. Forest Service compilation.
Thematic detail compiled by U.S. Forest Service.

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE

M7-SN-23916-7

Bedload point bar and log debris in Upper Entiat channel causing streamflow diversion.

Bedload point bars in Upper Entiat River. Many of these gravels are packed so tight with fine sediment that they have lost fish spawning value.

Appendix D
Flood Hazards
E.R. Artim, DNR

D. Flood Hazards

Information regarding the classification and location of alluvial fans in the Entiat Basin was extracted from a report by E. R. Artim of the Division of Geology and Earth Sciences in Olympia, Washington. This report and the accompanying large-scale topographic map served as the basis for the Surface Geology and Flood Hazards Map. A copy of Artim's topographic map is available for viewing at the Office of the Chelan County Regional Planning Commission, Wenatchee, Washington.

This report describes the relative hazard of flooding in the Entiat Valley and the Lake Chelan area of Chelan County, Washington. It is based on field investigations during the spring of 1974 as well as a review of available literature and aerial photo geology investigations. Factors taken into consideration included rainfall data, landforms, drainage areas, gradient, and drainage length.

The greatest potential problem of flooding for these areas could be from flash floods in tributary valleys and draws. The definition of flash flood is "a local and sudden storm or torrent of relatively great volume and short duration, overflowing a stream channel in an usually dry valley (as in a semiarid area), carrying an immense load of mud and rock fragments, and generally resulting from a rare and brief, but heavy rainfall over a relatively small area having steep slopes." (Gary, M., et al, 1972, *Glossary of Geology,* American Geological Institute, Washington, D.C., p. 264). During such a storm, the rainwater and debris are channeled into the drainage system and discharged as a torrent down in the incised channel and the alluvial fans. Such torrents have been clocked at 50 miles per hour and could obliterate anything placed in their path.

The major difference between flash flooding and flooding is control. As a river system approaches flood stage, sand bagging or other forms of artificial river levees can contain or confine the water within the river channel. Flash flooding rarely gives people the opportunity to even make an attempt at control. Flash floods occur in channels or on alluvial fans that are sometimes virtually free of surface water for years. Loose rock debris, dead vegetation, or other material collect over that period of time until that one intense storm occurs. The debris and water collect or rush down the channels and fans with such speed and intensity that there is no time to react.

The areas mapped by Artin are separated into five classes of decreasing hazard

Map	Unit	Physical Features and Flooding Characteristics	Flooding Probability	Suitability for Development
Red	1	Floodplain— continuous low flow or active flow with measurable rainfall high flow with intense rainfall. Liable to inundation by yearly floods.	100%	Not suitable
Yellow	2	Active alluvial fans and incised channels on inactive alluvial fans. Channels and active fans subject to inundation by flash flood debris during local intense storms of 10- to 100-year magnitude.	1-10%	Not suitable except for pasture, light agricultural use, forestry or day use recreational sites.
Orange	3	Floodplain—high flow with intense rainfall. Located immediately above high water mark of Unit 1. Liable to inundation by 50- to 100-year floods.	1-2%	Generally not suitable except for pasture, light agricultural use, or day use recreational sites.
Brown	4	Active alluvial fans and incised channels on inactive alluvial fans. Subject to inundations by flash flood debris during local intense storms of 100-year magnitude or greater.	Less than 1%	Marginal from safety standpoint for building for development; usable for heavy agricultural, pasture, forestry, or recreational sites.
Blue	5	Inactive alluvial fans and abandoned alluvial fans. Virtually free from problems of flash floods or flooding.	Fractional	Generally suitable for development.

Limitations

The delineation of flash flood hazard zones is made difficult by the lack of local flood records, the inherent difficulty of predicting the frequency and behavior of such events, and the fact that field studies for this project were of a reconnaissance nature.

The conclusions and opinions made in this Report are based on the presently available information and are made for land use planning purposes only. A detailed engineering and geology report is recommended for individual site evaluations within any of the hazard zones.

Appendix E
Sediment Analysis—Irrigation Systems

E. Sediment Analysis—Irrigation Systems

Analysis done by Wayne Kilgore, Agricultural Economist, Washington State Office, SCS

The following costs are stated to show the pre- and post-1970 fire conditions which resulted in increased sedimentation:

A. Sprinkler Nozzles (15 ac. orchard)

(1) Materials

Pre-fire —

Buy 50 sprinklers x $4	=	$200
Five years later replace them at $1.40	=	70
		$270 over 10 years
or $27 per year on 15 ac.	=	$1.80 per acre per year

Post-fire —

Fifty sprinklers total or approximately 4 per acre.

Each year 25 must be replaced at cost of $4	=	$100
Each year 25 must be repacked at cost of $1.40	=	35
		$135

$135 on 15 ac. = $9 per acre per year cost of sprinkler nozzles after fire.

(2) Labor

Prefire —

Every 10 years rebuild all sprinklers at 16 hrs. x $3/hr. = $48

$48/10 years = $4.80/yr/15 ac. = 32¢ per ac. per year

Post-fire —

Each year replace half at 8 hrs. x $3/hr. = $24.

$24 on 15 ac. = $1.60 per acre per year.

(3) Operation

Pre-fire —

Three hours per day to change, clean, move, etc.

Three hours x 150 days x $3/hr. = $1,350

$1,350/15 acres = $90 per acre per year.

Post-fire —

Five hours per day to change, clean, move, etc.

five hours x 150 days x $3/hr. = $2,250

$2,250/15 acres = $150 per acre per year.

Damages to Sprinklers:

Pre-Fire		Post-fire	**Average Annual Damages Per Acre**
$92.12 per ac.		$160.60 per ac.	$68.48
$68.48 x 1,600 acres	=	$109,568 average annual damages	

B. Pumps (average 1 h.p. per acre; cost $1,500 for 10 h.p. pump or $150 per h.p.)

(1) Materials
Pre-fire —
Average life = 20 years
$150/20 years = $7.50 per acre per year
Post-fire —
Average life = 5 years
$150/5 years = $30 per acre per year.

(2) Maintenance
(a) On pump
Pre-fire —
$10 for 10 h.p. pump for 10 ac. per year.
$10/10 ac. = **$1.00** per acre per year.
Post-fire —
$75 for 10 h.p. pump for 10 ac. per year.
$75/10 ac. = $7.50 per ac. per year.

(b) On sump
Pre-fire — (on 10 acres)
Clean sump ½ time with back hoe (2 hours at $25/hr.) = $50 x .5 = $25.
Hand labor = 8 hours x $3 = $25
$25 + $25 = $50/10 acres = $5 per acre per year.
Post-fire — (on 10 acres)
Clean sump 2 times with back hoe (2 hours at $25/hr.) = $50 x 2 = $100.
Hand labor = 33 hours x $3 = $100.
$100 + $100 = $200/10 acres = $20 per acre per year.

(3) Operation
Same size pumps requiring same fuel, etc. No difference in operational costs.

Damages to Pumps:

Pre-Fire	Post-fire	Average Annual Damages Per Acre
$13.50 per ac.	$57.50 per ac.	$44.00

$44.00 per acre x 1,600 acres = **$70,400** average annual damages.

C. Ditches.

(1) Maintenance
Pre-fire —
$1.00 per acre per year to maintain ditches.
Two-thirds of acres have ditches.
$1.00 x .67 = 67¢ per acre per year for maintenance
Post-fire —
$10 per acre per year to maintain ditches.
Approximately two-thirds of acres have ditches.
$10 x .67 = $6.70 per acre per year for maintenance.

Damages to Ditches:

Pre-Fire	Post-fire	Annual Damages Per Acre
$.67 per ac.	$6.70 per ac.	$6.03

$6.03 x 1,600 acres = $9,648 average annual damages

D. Yield

It is estimated that out of 160 trees per acre, on the average, 50 are young trees. Lack of water due to pumps being off to be cleaned, etc., has retarded growth in these young trees enough that net income on these trees is down $2 per tree per year. Fifty trees x $2 = $100 per acre x 1,271 = $127,100 average annual damages.

Total Agricultural Damage Due to Sedimentation = $316,715 Average Annual Damages.

Appendix F
Past Rehabilitation Efforts

F. Past Rehabilitation Efforts

The following reports contain details of the immediate rehabilitation treatments following the various fires.

1. Funding Needs for Restoration of the Fourth of July Mountain and Ardenvoir Fires
   August 26, 1968

2. Fire Rehabilitation
   Wenatchee National Forest
   September 11, 1968

3. Followup Report—Hornet Creek Fire Rehabilitation
   Entiat Ranger District
   August 1970

4. Mills Canyon Fire
   Rehabilitation and Reseeding Plan
   Entiat Ranger District
   August 1970

5. North-central Washington Fires
   Wenatchee and Okanogan National Forests
   Rehabilitation Report
   September 10, 1970

6. Fire Rehabilitation Report for the Gold Ridge, Entiat, Slide Ridge, and Mitchell Creek Fires
   Division of Watershed Management, Regional Office
   September 21, 1970

7. Operational Report of Rehabilitation of the North-central Washington Fires
   Perkins, R.F.; R.A. Woodward; T.P. Ryan,
   Wenatchee National Forest
   June 1971

8. Crum Canyon Fire Emergency Rehabilitation Report
   Entiat Ranger District
   December 1976

In addition, the following rehabilitation efforts have been undertaken by the District since the initial treatment measures. Items are keyed to the Critical Erosion and Rehabilitation Needs Map.

1. Additional check dams and trash racks. One trash rack and 12 check dams on Miiddle Fork Preston Creek; approximately 20 more check dams on McCree and Brennegan Creeks. Work was done in 1971 at cost of about $3,000. All these structures were lost in the June 1972 flood.

2. The Corps of Engineers contributed $34,000 worth of work in 1971 in removing woody debris from both Federal and private lands. Forest Service contribution to the debris removal work on Federal land was $17,000.

3. Rock pit slide was seeded and fertilized in March 1972 at cost of about $2,000.

4. Willow cuttings on Preston Creek by Boy Scouts (about 50 mandays work). 1972.

5. Channel change on Entiat River below Fox Creek in 1972 to protect road. $6,000.

6. Road reconstruction and repair following June 1972 flood. Approximately $130,000. (June 9-10, 1972 Flood Damage Report, Entiat Ranger Station, Wenatchee National Forest).

7. Maintenance of trash racks 1972-1974 — $1,332. Only three trash racks remain (on Kloochman, Tillicum, and Burnett Creeks).

8. Repair to flood damaged trails on Silver and Fox Creek, 1972 for $2,100.

9. Tillicum Creek grade control project. Total of 166 drop structures installed 1972-1973 at cost of about $4,000.

10. Fertilization of raw soils in Brennegan Creek salvage area, 1973 for $6,000.

11. Followup fertilization of roads and skid trails in McCree Creek and Burns Drainage, 1973 for $2,700.

12. Fertilized 532 acres of fireline near Shady Pass in 1973 for $10,400.

13. Seeding and water barring in Brennegan Creek salvage area in 1973 for $4,500.

14. Shrub planting on Preston Creek in 1974 at cost of about $2,000. Little has survived.

15. Mills Canyon stream cleanout in 1974 at cost of $500.

16. Dill Creek channel change above county road in 1974 at cost of $350.

17. Seeded and fertilized French Corral Slide, 1973 for $400. Drain installation in slide in 1974 at cost of about $15,000.

18. Salvage sale and cleanup of jams and debris on Entiat River (¾-mile stretch below Silver Creek and a ½-mile stretch below Fox Creek — $4,000 in 1974.)

19. Natural log jam removed on Mad River in 1974 for $5,000.

20. Construction of spawning channel on Entiat River below Fox Creek in 1976. Cost: $13,000 Forest Service funds and $25,000 State funds equalling $38,000.

21. Check dam construction, gabion revetment construction, shrub planting, stream cleanout, water bar repair, spot seeding and fertilizing on Preston and Brennegan Creeks. Title X (CETA) project, 1976 at cost of $31,000.

22. One mile of light debris cleanout on lower Indian Creek by Boy Scouts in 1977.

23. Seeded and fertilized in October 1976 (Crum Canyon Fire Rehabilitation) 310 acres.

24. Hand terraced and seeded in September 1977. 15 acres.

25. Two hundred acres treated as in #23. Also machine and hand terraced, seeded and fertilized September 1977.

26. Somewhat related to the overall picture is the Potato Creek Erosion Control Project which treated 110 acres in 1958 following impact by logging and grazing. Cost of this project was $4,400.

Appendix G
Feasible Land Treatment Needs on National Forest Lands

G. Feasible Land Treatment Needs on National Forest Lands

(In Order of Importance)

Item #	Type of Work	Units	Total Units	Cost (In M.$)	Remarks
1	Woody debris removal	miles	24.0 (7.5)	41 (10)	$5,000/year additional to maintain clear channel; mostly hand work; major jam in Fox Creek (NWNE¼, Section 17).
2	Streambank stabilization by revetment	feet	300	19	Single tier gambion & apron; one of the two sites is accessible by machine.
3	Streambank stabilization by shrub planting	miles	15.2 ((8.5))	33 ((4))	$5,000/year additional for 5 years to interplant, 3x3 foot spacing of rose, penstemon or elderberry. Must gather seed and get to nursery 1½ years in advance.
4	Site Prep on rilled soils	acres	((810))	((162))	To break up erosion pavements, under 216 request.
5	Seeding and Fertilizing	acres	((810))	((36))	
6	Gully Control	acres	85 ((8))	49 ((16))	Terrace, dense planting to shrubs and pine.
7	Road cut & fill stabilization	feet	5200	8	At stream crossings; treat by mulch and shrub planting.
8	Snag felling	acres	100	15	Need more obstacles on contour to trap sediments from overland flow.
9	Road closures	each	20	10	By earth barriers/short obliteration; pursuant to objectives of E.D. 10.
10	Road water dips added	each	14	2	
11	Check dams	miles	1.8 ((0.4))	21 ((5))	Series of low 30 inch wire and rock dams; $2,000/year additional for maintenance.
12	Fertilize	acres	2050	43	Consists of 240 acres of shrub planted streambanks, 1810 acres refertilization.
13	Water bar repair	Extensive		5	

Item #	Type of Work	Units	Total Units	Cost (In M.$)	Remarks
14	Sediment removal	yards³	35,000	14	Reshaping gravel bars to improve direction of flow and site prep for planting.
15	Sediment stabilization	acres	101	15	Dense (3x3 foot) planting of willow and alder cuttings and transplants.
16	Revegatation by shrubs	acres	65 (19)	25 (10)	On marginal forest land not scheduled for reforestation; within 2 chains of stream.
17	Road water dips added	each	14	2	
18	Culvert headwalls	each	25	4	To keep pumice dry gravel from plugging.
19	Hand-placed riprap	Extensive		4	In areas of poor access.
20	Culvert added	feet	75	1	Needs extension to prevent erosion at outflow.
21	Reforestation of marginal forest land	acres	1692*	588	4985 acres of commercial forest land is already scheduled for reforestation throughout the basin by 1984 at estimated cost of $1,312,000.

*Breakdown by Sub-Basin: 364 acres in II, 846 acres in IV, 482 acres in V.

NOTE: (Sub-Basin V), ((Sub-Basin II)), ALL OTHERS - Sub-Basin IV.

Appendix H
Fireline Inventory and Road Inventory

H. Fireline Inventory and Road Inventory

Entiat Watershed Fireline Inventory
(In Miles)

Sub-Basin	Regular Firelines[1]				Shaded Fuelbreaks[2]				Total miles for Sub-Basin
	Slope		Width		Slope		Width		
	>40%	<40%	>2 ch.	<2 ch.	>40%	<40%	>2 ch.	<2 ch.	
I	2.5	10.5	2.0	11.0	0.5	1.5	0	2.0	15
II	2.2	9.8	5.0	7.0	0.5	2.5	0	3.0	15
III	2.5	6.3	5.8	3.0	0	0	0	0	8.8
IV	4.5	13.0	0	17.5	0	0	0	0	17.5
V	6.0	16.0	6.5	15.5	0	0	0	0	22.0
VI	0	0	0	0	0	0	0	0	0
TOTAL	17.7	55.6	19.3	54.0	1.0	4.0	0	5.0	78.3

[1]Litter layer removed to mineral soil.

[2]Large litter removed, soil profile intact.

Sub-basins were arbitrarily numberd as follows:

- I area below Roaring Cr. bridge (hatchery bridge)
- II Entiat River between USGS gage and Roaring Cr. bridge
- III area between Preston Cr. and USGS gage
- IV area between Entiat Falls and Preston Cr.
- V Mad River above Ardenvoir intake
- VI Entiat River above Entiat Falls

All tables reflect the revised boundary between sub-basins I and II.

Entiat Watershed Road Inventory
(In Miles)

Sub-Basin	Maintained: Paved 2 Lane	Maintained: Paved 1 Lane	Maintained: Gravel Surface	Maintained: Unsurfaced	Unmaintained Unsurfaced	Total
I	5.5	0.1	5.3	8.0	98.7	117.6
II	12.0	0.3	12.0	134.5	62.6	221.4
III	5.0	0	0	14.6	23.6	43.2
IV	11.3	7.8	10.2	52.3	28.7	110.3
V	0.5	1.0	1.9	99.3	83.2	185.9
VI	1.0	0.5	2.4	12.6	2.4	18.9
TOTAL	35.3	9.7	31.8	321.3	299.2	697.3

NOTE: All are single lane except as noted.
Includes country roads.

Sub-basins were arbitrarily numberd as follows:

- I area below Roaring Cr. bridge (hatchery bridge)
- II Entiat River between USGS gage and Roaring Cr. bridge
- III area between Preston Cr. and USGS gage
- IV area between Entiat Falls and Preston Cr.
- V Mad River above Ardenvoir intake
- VI Entiat River above Entiat Falls

All tables reflect the revised boundary between sub-basins I and II.

Appendix I
Status Report—
Washington State Game Department

I. Status Report—Washington State Game Department

United States Forest Service
AP&D
P.O. Box 3623
Portland, Oregon 97208

I find that we have no formalized plan available for the Entiat Unit of the Colockum WRA since it is not a Federal aid project so will present you with what we have in mind for the area.

First, lands actually owned by the Game Department have not been so severely affected by erosion as adjacent lands, so corrective needs on State Game lands may not be as extensive as other lands within the Crum Canyon-Entiat drainage.

At present, we do have a sharecrop-wheat farming arrangement on about 400 acres within Crum Canyon, about half of which is within the 1970 burn. We plan to continue this program about as it is, with a summer fallow-winter wheat arrangement.

After the 1970 burn, we did replant about 600 acres within the burn to bitterbrush, legumes, and other plants beneficial to wildlife. In addition, we want to leave untouched the west end of what is known as the Old Roundy Place, which is part of the Entiat area. This area is becoming revegetated with ceanothus, a plant species valuable to wildlife.

In the burned area, we intentionallly left snags standing for the use of birds and also to help break winter winds for the benefit of wildlife.

Concerning plans for the future, we intend to accomplish the following as time and funds become available:

1. Install two or three cisterns in and adjacent to the old burned area for the use of upland game birds.

2. Reseed small areas within the burn to clover.

3. Revegatate portions of Bird Canyon and Oklahoma Gulch.

As far as recommendations to the Forest Service, one project we feel would be worthwhile would be to reseed Forest Service land within Bird Canyon to bitterbrush. This area is a valuable deer wintering area, and also, additional vegetation may help hold the land in this unstable area which has been known for "flushouts" into the Columbia River, adversely affecting water quality and upland habitat alike. Although this project would not directly benefit Crum Canyon and the Entiat River, it is a serious environmental problem.

We presently have no recommendations for Crum Canyon or the Entiat River directly. I would suggest you stay in touch with Larry Brown and Lewis Lund on that matter.

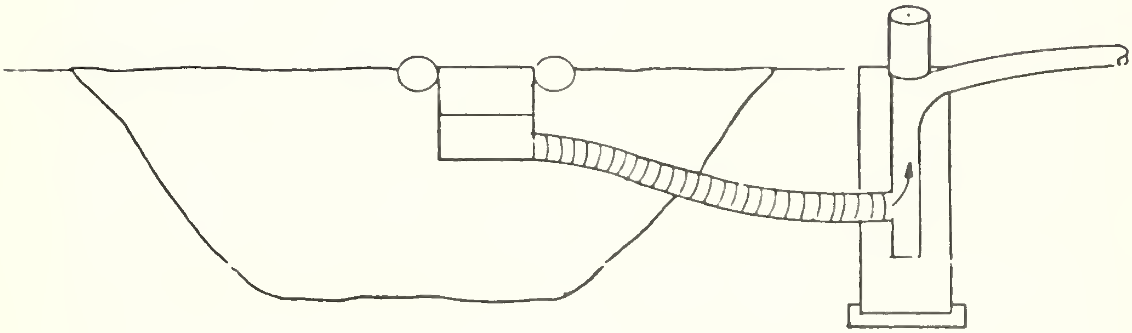
Douglas Fletcher
Regional Environmentalist

Appendix J
Diagrams—
Sediment Pond, Rainey Collector

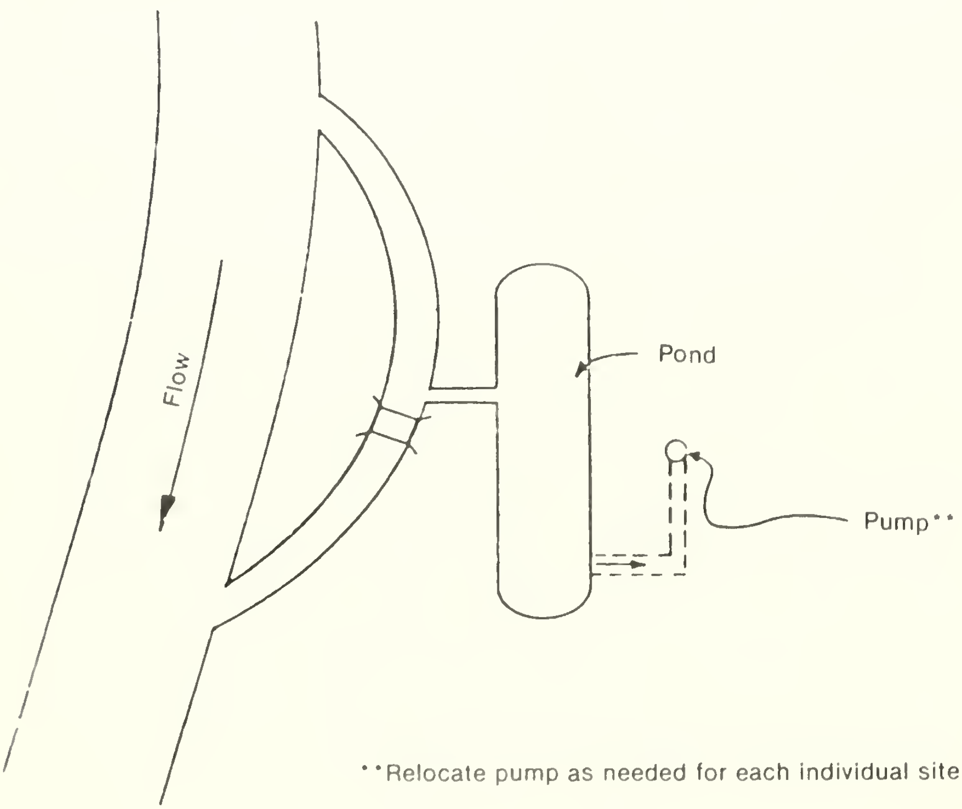
J. Diagrams—Sediment Pond, Rainey Collector

Sediment Pond*

Floating Foot Valve

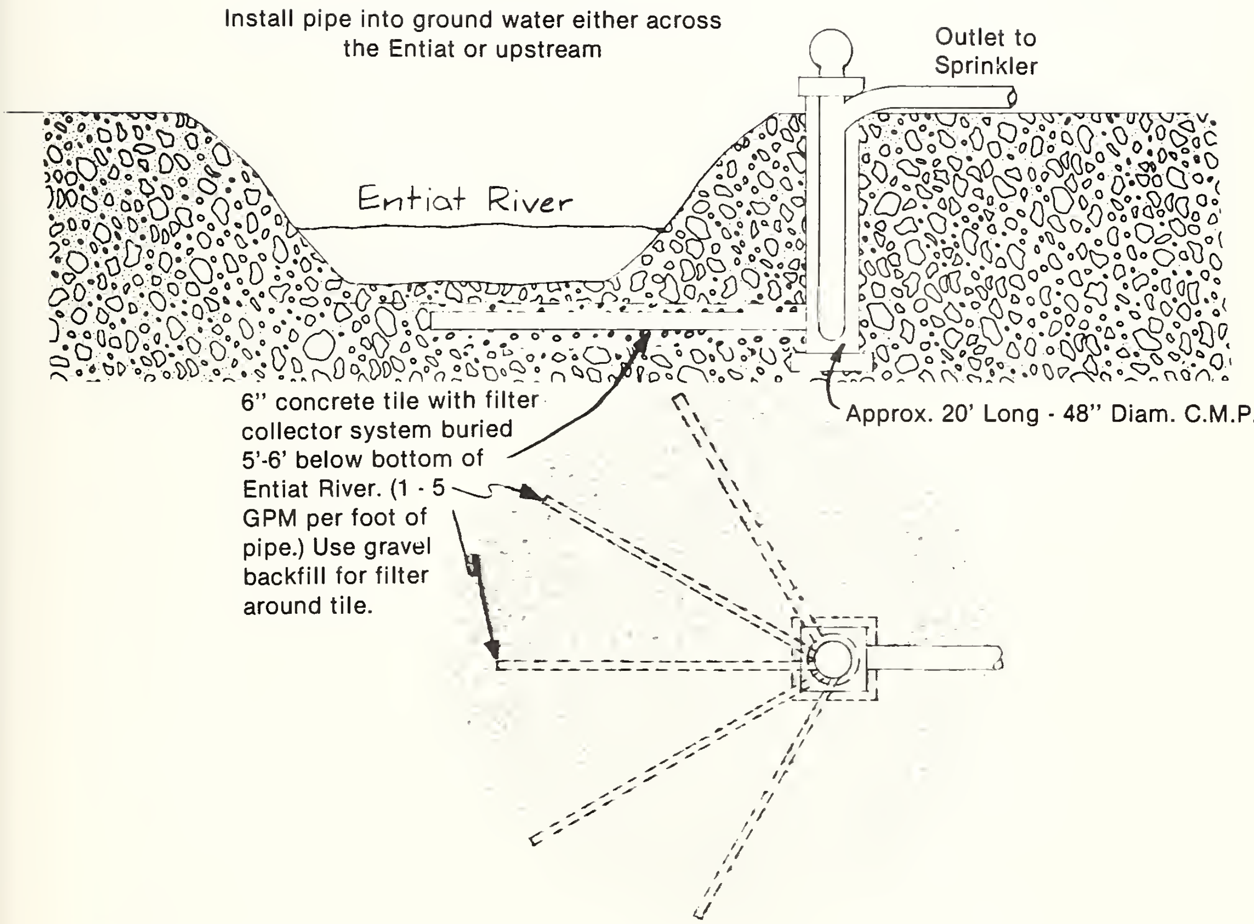


*Pond size & shape to depend on amount of water to be pumped and available space.



**Relocate pump as needed for each individual site.

Rainey Collector*
(Horizontal Well)



*Each installation will require on-site investigation.

Appendix K
Soil Description Briefs

K. Soil Description Briefs

Two interpretive maps, based largely on soil survey data, have been developed for this Study. They are the Hydrologic Soil Groups Map and the Surface Erosion Potential Map. The Hydrologic Soil Groups Map depicts soil groups with varying hydrologic response. This response is related to soil infiltration rates, soil depth, land slope, and is the ability of that soil mantel to store and gradually release ambient precipitation. The Surface Erosion Potential Map compares the relative rapidity and amount of erosion by water after removal of protective vegetation and organic layer. The ratings were made after considering the effects of soil structure, texture, depth, permeability, slope, bedrock type and degree of fracturing, rate of geologic erosion, and from visual observations. Since these ratings are based on the soil's inherent capacity to erode, climatic factors such as storm intensity or frozen soil conditions are not considered. Although these were developed for this Study's analysis, they may serve as tools for land managers.

The following are from the publication "Soil Survey of Chelan Area, Washington."[9] Refer to Figure 8 for map of associations.

Entiat-Dinkelman — Dominantly moderately coarse textured, steep, and very steep soils underlain by bedrock at a depth of 14 to 60 inches; on uplands.

This association occupies approximately 57 percent of the lower valley and is on the top and sides of ridges and mountainous uplands. The soils formed in decomposing granodiorite and granite. Vegetation is bluebunch wheatgrass, sedges, bluegrass, balsamroot, lupine, bitterbrush, scattered Douglas-fir, and ponderosa pine. These soils have a moderately rapid permeability. On slopes less than 25 percent, runoff and erosion hazard is slight to moderate. On steeper slopes, runoff is rapid to very rapid and the erosion hazard is high to very high.

Nard-Stemilt — Dominantly medium-textured, steep, and very steep soils underlain by bedrock below a depth of 40 inches; on uplands. This association occupies approximately 17 percent of the lower valley and is on ridgetops, foothills, sides of terraces, and on mountainous uplands. It consists mainly of well-drained soils. Vegetation is mainly ponderosa pine, Douglas-fir, bluebunch wheatgrass, other grasses, lupine, serviceberry, and ceanothus. Permeability is slow to moderate, runoff varies from slow on gentle slopes to very rapid. Erosion hazard varies correspondingly from slight to very high.

Brief-Leavenworth — Dominantly moderately coarse textured, nearly level to strongly sloping soils on bottom lands, low terraces, and alluvial fans.

This association occupies approximately 14 percent of the lower valley and is on bottom lands, low terraces, and alluvial fans along the Entiat River. These soils were formed in alluvium. Natural vegetation is willow, alder, sedge, pine grass, forbs, Douglas-fir, and ponderosa pine. (These soils, too, are irrigated for orchard, hay, and pasture.) The two principal soils in this association have a moderate to moderately rapid permeability. Runoff is very slow and the hazard of erosion is slight to moderate.

Antione-Jumpe — Dominantly medium-textured, strongly sloping to steep soils, many of which are shallow or stony; on uplands.

This association occupies approximately 5 percent of the lower valley, and is on the top and sides of ridges north of the Entiat River. The soils formed in weathered basalt, but have a surface layer of loess and ash. They are well drained. Vegetation is mainly Douglas-fir, larch, lodgepole pine, ponderosa pine, pine grass, sedge, some forbs, and shrubs. For the two principal soils, permeability is moderate, runoff is medium to rapid, and erosion hazard is moderate to high.

Burch-Cashmont — Dominantly medium-textured, and moderately coarse textured, nearly level to strongly sloping soils on terraces, alluvial fans, and foot slopes.

This asociation occupies approximately 3 percent of the lower valley, and is on terraces and low, recent alluvial fans near the mouth of the Entiat River. The major soils in this association have some loess and volcanic ash near the surface. Native vegetation is bunchgrass, forbs, and shrubs, but much is in irrigated orchard, hay, and pasture. These soils have a moderate to moderate-

ly rapid permeability, runoff is very slight to moderate and the hazard of erosion is slight to moderate.

Bjork-Zen — Dominantly medium-textured, steep soils underlain by bedrock at a depth of 20 to 40 inches; on uplands.

A small acreage of this association is about 2 percent of the lower valley, and is on terraces and side slopes north of the Entiat River. The soils are well-drained. They formed in loess or weathered sandstone and schist with some surface ash. Vegetation is bluebunch wheatgrass, bluegrass, bitterbrush, sagebrush, and in places scattered ponderosa pine. Bjork Series soils have a moderate to slow permeability, rapid to very rapid runoff, and high to very high erosion hazard. They make up 39 percent of the association. Twenty-six percent are Zen Series which have a moderate permeability, runoff, and hazard to erosion.

Rock Outcrop-Rock Land-Terrace Escarpments — Dominantly steep and very steep to nearly vertical areas of rock outcrops, very shallow and shallow soils over rocks and terrace breaks.

This association occupies approximately 2 percent of the lower valley. Where there is vegetation it is mainly bunchgrass, scattered ponderosa pine, and Douglas-fir.

The following are from the publication "Soil Management Report, Entiat Area."[2]

Rockland-Fernow-Maude — Occupies about 26,900 acres in the headwaters of the Entiat Basin. Rocklands (including rock outcrop) occupy 60 percent. Fernow and Maude each occupy 10 percent. Annual precipitation ranges from 50 to 100 inches, primarily as snow. In some places there is a thin stony soil. Few trees and only scattered shrubs and herbaceous plants are present. These soils are highly erodible.

Pugh-Rockland — Occupies about 50,600 acres in the upper Basin. Mean annual precipitation ranges from 45 to 70 inches, occurring primarily as snow. Overstory vegetation is Douglas-fir, lodgepole pine, subalpine fir, and Pacific silver fir. The Pugh soils are highly erodible.

Choral-Rampart — Occupies about 76,300 acres. It lies mostly within the principal forest resource zone. Most of these soils were formed in deep pumice deposits, but a few were formed in fluvioglacial materials along the Entiat River. Precipitation averages from 35 to 60 inches and is mostly snow. These soils are well-drained, moderately coarse textured, derived from volcanic ash and pumice. They are highly erodible when disturbed.

Tyee-Morical-Dinkleman — Occupies about 37,500 acres with the majority occurring within the principal forest resource zone and the remainder in the grass-shrub resource zone. There are many intermittent streams. Most soils have formed in weathered granodiorite and quartz diorite. The mean annual precipitation ranges from 10 to 30 inches. South slopes usually contain patchy ponderosa pine, with an understory of cheatgrass, balsamroot, bitterbrush, and big sagebrush. North slopes have a medium stocking of Douglas-fir and ponderosa pine. These soils are moderately to excessively well-drained. They are highly erosive, especially on steep slopes, but the Tyee, which usually occurs on south slopes, are the most critical.

McCree-Palmich-Bisping — Occupies about 21,300 acres in the principal forest resource zone. Soils are formed from weathered granodiorite and quartz diorite, and from a mixture of these and pumice and ash. The mean annual precipitation ranges from 20 to 49 inches occurring primarily as snow. These soils are well-drained. Palmich and Bisping soils occupy 40 percent of the association and are moderately resistant to erosion when disturbed. McCree soils are highly erosive on steep slopes.

Ardenvoir-Tyee-Chumstick — Occupies about 56,400 acres. It occurs primarily in the principal forest resource zone with a small portion in the grass-shrub resource zone. Most of the area is very steep and is composed of granodiorite, gneiss, and schist bedrock which, when weathered, is the soil parent material. At lower elevations trees are scattered, especially on south and west facing slopes. Soils are well-drained. Fifty-five percent of the association are Ardenvoir and Chumstick soils which are moderately resistant to erosion. Tyee soils are highly erodible and, where vegetation is thin, intense storms will cause accelerated erosion on roads.

Sourdough-Alma-Tillicum — Occupies about 21,000 acres. The mean annual precipitation is from 35 to 40 inches and occurs primarily as snow. Soils are well-drained. They are moderately resistant to erosion on gentle slopes, but are erodible on steep slopes.

Appendix L
Channel Stability

Above — Development of alluvial fan seriously damaged by 1972 flooding. Such areas due to break in slope are natural deposition and water spreading areas.

Right — Stable reach of Entiat tributary mainly due to large rocks which act as channel armor and energy dissipaters of flow.

L. Channel Stability [16]

The purpose of applying a procedure to determine stream channel stability is to systemize measurements and evaluate the resistive erosion capacity of mountain stream segments to the detachment of bed and bank materials and to provide quantified information about the capacity of streams to adjust and recover from potential changes in flow and/or increases in sediment production.

The procedure evaluates 15 characteristics which are further described. Keep in mind that this system was and must be applied in the field. More detailed information on the methodology can be obtained from the cited reference.

Upper Channel Banks

The land area immediately adjacent to the stream channel is normally and typically a terrestrial environment. Landforms vary from wide, flat, alluvial floodplains to the narrow, steep termini of mountain slopes. Intermittently this dry land floodplain becomes a part of the water course. Forces of velocity and turbulence tear at the vegetation and land. These hydrologic forces, while relatively short lived, have great potential for producing onsite enlargements of the stream channel and downstream sedimentation damage. Resistance of the component elements on and in the bank are highly variable. This section is designed to aid in rating this relative resistance to detachment and transport by floods.

Landform Slope. The steepness of the land adjacent to the stream channel determines the lateral extent and ease to which banks can be eroded and the potential volume of slough which can enter the water. All other factors being equal, the steeper the land adjacent to the stream, the greater the potential volume of slough materials.

The 60 percent limit for poor was selected as a conservative gravitational repose angle for unconsolidated soil materials. Slopes steeper than this are rated poor because they would erode into the stream by gravity alone, if denuded of their protecting vegetation. The other ratings built on this limit and are arbitrarily set as follows:

Mass Wasting Hazard. This rating involves existing or potential detachment from the soil mantle and downslope ground. Mass movement of banks by slumping or sliding introduces large volumes of soil and debris into the channel suddenly, causing constrictions or complete damming followed by increased streamflow velocities, cutting power, and sedimentation rates. Conditions deteriorate in this element with proximity, frequency, and size of the mass wasting areas and with progressively poorer internal drainage and steeper terrain.

Debris Jam Potential. Floatable objects are deposited on streambanks by man and as a natural process of forest ecology. By far, the bulk of this debris is natural in origin. Tree trunks, limbs, twigs, and leaves reaching the channel form obstructions, flow deflectors, and sediment traps. This inventory item assesses the potential for increasing these impediments to the natural direction and force of flow where they now lay. It also includes the possibility of creating new debris jams under certain flow conditions.

Vegetative Bank Protection. The soil in banks is held in place largely by plant roots. Riparian plants have almost unlimited water for both crown and root development. Their root mats generally increase in density with proximity to the open channel. Trees and shrubs generally have deeper root

systems than grasses and forbs. Roots seldom extend far into the water table, however, and near the shore of lakes and streams they may be comparatively shallow rooted. Some species are, therefore, subject to windthrow.

In addition to the benefits of the root mat in stabilizing the banks, the stems help to reduce the velocity of flood flows. Turbulence is generated by stems in what may have been laminar flow. The seriousness of this energy release depends on the density of both overstory and understory vegetation. The greater the density of both, the more resistance displayed. Damage from turbulence is greatest at the periphery and diminishes with distance from the normal channel. Other factors to consider, in addition to the density of stems, are the varieties of vegetation, the vigor of growth, and the reproduction processes. Vegetal variety is more desirable than a monotypic plant community. Young plants, growing and reproducing vigorously, are better than old, decadent stands.

Wood debris from Burn is causing river flow deflection and accelerated bank erosion.

Lower Channel Banks

The channel zone is located between the normal high water and low water lines. Both aquatic and terrestrial plants may grow here but normally their density is sparse.

The lower channel banks define the present stream width. Stability of these channel banks is indicated under a given flow regimen by minor and almost imperceptible changes in channel width from year to year. In other words, encroachment of the water environment into the land environment is nil.

Under conditions of increasing channel flow, the banks may weaken and both cutting (bank encroachment) and deposition (bank extension) begin, usually at bends and points of constriction. Cutting is evidenced by steepening of the lower banks. Eventually the banks are undercut, followed by cracking and slumping. Deposition behind rocks or bank protrusions increase in length and depth.

As the channel is widened, it may also be deepened to accommodate the increased volume of flow. For convenience only, changes of channel bottoms are observed separately and last in this evaluation scheme.

Channel Capacity. Channel width, depth, gradient, and roughness determine the volume of water which can be transmitted. Over time channel capacity has adjusted to the size of watershed above the reach rated, to climate, and to changes of vegetation. Some indicators of change are widening and/or deepening of the channel which affects the ratio of width to depth. When the capacity is exceeded, deposits of soil are found on the banks and organic debris may be found hung up in the bank vegetation. These are expressions of the most recent flood event. Indicators of conditions as recent as a year or two ago may be difficult or impossible to find, but do your best to estimate what normal peak flows are and whether the present cross section is adequate to handle the load without bank deterioration.

Bank Rock Content. Examination of the materials that make up the channel bank will reveal the relative resistance of this component to detachment by flow forces. Since the banks are perennially and intermittently both aquatic and terrestrial environments, these sites are harsh for most plants that make up both types. Vegetation is, therefore, generally lacking and it is the volume, size and shape of the rock component which primarily determines the resistance to flow forces.

Obstructions and Flow Deflectors. Objects within the stream channel, like large rocks, embedded logs, bridge pilings, etc., change the direction of flow and sometimes the velocity as well. Obstructions may produce adverse stability effects when they increase the velocity and deflect the flow into unstable bottom materials. They also may produce favorable impacts when velocity is decreased by turbulence and pools are formed.

Sediment Traps. Channel obstructions which dam the flow partly or wholly form pools or slack water areas. The pools lower the channel gradient. With this loss of energy the sediment transport power is greatly reduced. Coarse particles drop out first at the head of the pool. Some or all of the fine suspended particles may carry on through.

Embedded logs and large boulders can produce very stable natural dams which do not add to channel instability. Some debris dams and beaver dams, however, are quite unstable and only serve to increase the severity of channel damage when they break up.

The effectiveness of these sediment traps depends on pool length relative to entrance velocity. The swifter the current, the longer the pool needed to reach zero velocity. Turbulence caused by a falls at the head of the pool shortens the length required to reach zero velocity.

How long these traps are effective depends on depth and width as well as pool length and, of course, the rate of sediment accretion.

Items of vegetation growing in the water, like alders, willows, cattails, reeds, and sedges, are also effective traps in some locations and reduce flow velocity and sediment carrying power.

Cutting. One of the first signs of channel degradation would be a loss of aquatic vegetation by scouring or uprooting. Some channels are naturally devoid of aquatic plants and here the first stages would be an increase in the steepness of the channel banks. Beginning near the top, and later extending in serious cases to the total depth, the lower channel bank becomes a near vertical

wall.

If plant roots bind the surface horizon of the adjacent upper bank into a cohesive mass, undercutting will follow. This process continues until the weight of overhang causes the sod to crack and subsequently slump into the channel. Differential horizontal compaction and texture could also result in undercut banks even with an absence of vegetative cover. There are some loosely consolidated banks that with or without vegetation are literally nibbled away, never developing much, if any, overhang.

Deposition. Lower bank channel areas are generally the steeper portions of the wetted perimeter and may be rather narrow strips of land that offer slight opportunity for deposition. Exceptions to this statement abound since deposition is often noted on the lee side of large rocks and log deflectors which form natural jetties. However, these deposits tend to be short and narrow. On the less steep, lower banks, deposition during recession from peak flows can be quite large. The appearance of sand and gravel bars where they did not previously exist may be one of the first signs of upstream erosion. These bars tend to grow, primarily in depth and length, with continued watershed disturbance(s). Width changes are in a shoreward direction as overflow deposition takes place on the upper banks. Dimensional deposition "growth" is limited by the size and orientation of the obstructions to flow along the channel banks, flow velocity, and a continuing upstream sediment supply.

Deposition may also occur on the inside radii of bends, particularly if active cutting is taking place on the opposite shore. Also, deposits are found below constrictions or where there is a sudden flattening of stream gradient as occurs upstream above geologic nick points.

Section of unstable Entiat River; note log debris causing stream flow diversion.

Channel Bottom

Water flows over the channel bottom nearly all of the time in perennial streams. It is, therefore, almost totally an aquatic environment, composed of inorganic rock constituents found in an infinite variety of kinds, shapes, and sizes. It is also a complex biological community of plant and animal life. This latter component is more difficult to discern and may, in fact, at times and places, be totally lacking.

Both components, by their appearance alone and in combination, offer clues to stability of the stream bottom. They are arbitrarily separated and individually rated for convenience and emphasis during the evaluation process. Because of the high reliance on the visual sense, inventory work is best accomplished during the low flow season and when the water is free of suspended or dissolved substances. If ratings must be made in high flow periods, sounds of movement may be the only clue as to the state of flux on the bottom.

Angularity — Rocks from stratified, metamorphic formations break out and work their way into channels as angular fragments that resist tumbling. Their sharp corners and edges wear and are rounded in time, but they resist the tumbling motion. These angular rocks pack together well and may orient themselves like shingles (imbricated). In this configuration they are resistant to detachment.

In contrast, igneous rocks often produce fragments that round up quickly, pack poorly, and

The Mid-Entiat River meanders through a meadow of fine deposits. Banks are very unstable due to lack of rock content and the absense of deeply rooted vegetation.

A very unstable reach of the Upper Entiat River. Bedload and accelerated channel migration contributes to a sediment load of about 200 tons per mile per year. Note riprap effort to stabilize the bank.

are easily detached and moved downstream.

Excellent to **Poor** ratings relate to the amount of rounding exhibited and, secondarily, the smoothness or polish the surfaces have achieved. Some rocks never do smooth up in the natural environment, but most round up in time. Both conditions, of course, are relative within the inherent capability of the respective rock types.

Brightness — Rocks in motion "gather no moss," algae, or stain either. they become polished by frequent tumbling and, as a general rule, appear brighter in their chroma values than similar rocks which have remained stationary. The degree of staining and vegetative growths relate also to water temperature, seasons, nutrient levels, etc. In some areas a "bright" rock will be "dulled" in a matter of weeks or months. In another it may take years to achieve the same results. Nevertheless, even slight changes during the spring runoff should be detectable during the next summer's survey. Look first for changes in the sands and gravels.

Consolidation (Particle Packing) — Under stable conditions, the array of rock and soil particle sizes pack together. Voids are filled. Larger components tend to overlap like shingles (imbricate). So arranged, the bottom is quite resistant to even exceptional flow forces. Some rock types (granitics) are less amenable to this packing process and never reach the stable state of others.

Bottom Size Distribution and Percent Stable Materials — Rocks remaining on a stream's bottom reflect the geologic sources within the Basin and the flow forces of the past. Normally, there is an array of sizes that you expect to see in any given locale. After a little experience, you begin to "sense" abnormal situations. Generally, in the mature topography typical of the Northern Region of the Forest Service and much of the other Western Regions as well, the flow in the small, steep upper stream reaches is sufficient to wash the soil separates and some of the gravels away. What remains is a gravelly, cobbly stream bottom. In the lower reaches where the gradient is less and flow is often slower, deposition of the "fines" eroded above begin to drop out. The separates of sand, silt, and some clay begin to cover the coarser elements. Except where trapped in still

A reach of the Lower Entiat River in excellent stream stability condition. Stream sediment load contribution is only about 1 ton/mile/year.

water areas, these fines tend to be in constant motion to ever lower elevations.

Two elements of bottom stability are rated in this item: (1) Changes or shifts from the natural variation of component size classes, and (2) the percentage of all components which are judged to be stable materials. Bedrock, large boulders, and cobble stones range in size from 1 to 3 feet or more in diameter are considered "stable" elements in the average situation. Obviously, smaller rocks in smaller channels might also be classed as stable. The sizes are given only to guide thought. **Bedrock** as a major component of bottom and banks, no matter what size the channel or how the other elements rate, **always** results in an **excellent** classification of that reach.

Scouring and/or Deposition — Items of size, angularity, and brightness already rated above should lead you to some conclusions as to the amount of scouring and/or deposition that is taking place along the channel bottom.

Aquatic Vegetation — When some measure of stabilization of the soil-rock components is achieved, the channel bottom becomes fit habitat for plant and animal life. This process begins in the slack water portions of the stream cross section. With a change in volume of flow and/or sedimentation rates, there may also be a temporary loss of the living elements in the aquatic environment. This last item attempts to assess the one macro-aquatic biomass indicator found to best express a change in channel stability.

Clinging Moss and Algae — These lower plant forms do not have roots but cling to the substrate. They are low growing and may first appear as a green to yellow-green slick spot on the bottom rocks. Moss plants continue with slight variation in color but no great change in mass from season to season. Algae by contrast have a peak of growth activity and then die off in great numbers. The slippery conditions they produce persist after death, however.

Both algae and moss inhabit the swift water areas as well as the quiet pools and backwater portions of the stream bottom.

Brush plantings such as willow will help stabilize much of the Upper Entiat floodplain.

Several bedload deposits restrict channel capacity and threaten bridges, highways, and streambanks by accelerating channel lateral migration.

Appendix M
Physical Water Quality

Crum Canyon fire-flood area. Note sheet and rill erosion scars and intermittent stream channel scour.

M. Physical Water Quality

The Erosion and Sediment Sources

Erosion is the process by which soil and minerals are detached and transported by water, wind, and gravity, while sedimentation refers to the deposition of eroded material. Sediment load is the total amount of material carried by a stream, and turbidity is a measure of opaqueness or cloudiness of a stream due to sediment. Erosion and sedimentation, as natural processes, are integrally woven in the hydrologic cycle. In the Entiat River Basin, a large portion of annual sediment yield occurs during peak snowmelt runoff. As much as 80 percent of the Basin's annual sediment load may be associated with this peak discharge.

A number of erosional processes are involved in providing a source of sediment, including streambed and bank erosion, surface and subsurface soil erosion, mass soil and hillslope movements, and freeze-thaw action on rock and soil material. Streams also act as both agents of erosion and media for sediment transport. The size of load a stream can carry changes with channel geometry and rates of flow along the stream. Winter rains or spring snowmelt will enable swelling streams to attack bank and bed material previously untouched by or resistant to the stream's power.

Surface soil erosion and mass soil movement are perhaps more subject to acceleration by man. Surface soil erosion involves the detachment of soil particles by raindrop impact and subsequent transport of overland waste flow. Progressive concentration of this surface runoff results in additional erosion and the formation of rills and gullies. Surface erosion will normally take place only when sufficient energy is available to detach soil particles and sufficient moving water is available to carry materials away. Slope steepness and length also influence erosion by affecting runoff velocity and flow concentration.

Jammer road system, exposed by the Burn, enabled salvage following the 1970 fire. 90 million board feet of timber were recovered from salvage logging effort.

Mass movement in pumice soils has been accelerated by road runoff.

Effect of Roads and Road Construction

Cutting the toe of slope with road grader will cause accelerated erosion due to new unstable angle of repose.

The amount of erosion from roads will be a function of road density, location, and care exercised in construction and maintenance. Roads, whether logging roads, skid trials, firelines, or interstate highways, will increase surface erosion to the extent that bare soil is exposed to forces of rainfall impact and overland flow. The construction phase often results in greatest disturbance, and during this period significant increases in erosion and sediment load may be witnessed. Initially high sediment loads decline rapidly in the years after construction. Road densities associated with timber harvest activities vary with logging systems and resulting exposed mineral soil on 1 to 30 per cent of the logged area.

Roads also have a dominant effect on occurrence of mass soil movement, especially when roads are cut across the midslope of steep hillsides. Cutting into the slope effectively steepens the angle of repose and intercepts natural water flow down slopes. Sidecasting of cut material steepens the lower slope. Runoff from the road surface may be rerouted causing areas to become saturated. Obviously, by avoiding potential mass movement hazards in road location and by exercising care during and after road construction, sediment contribution to streams can be minimized.

Excellent effort to minimize erosion of road fill slope in the Mad River Watershed by piping water down slope.

This area is typical of dry creep, colluvial erosion process that ocurs on steep slopes.

Vegetation and associated organic litter play a key role in inhibiting surface erosion by first, absorbing rainfall impact; second, by promoting soil aggregation and increasing infiltration; and third, by offering physical resistance to overland flow.

Mass movements of material — landslide, slumps, debris slides, etc. — are normal and frequent in the evolution of mountain landscapes occurring predominantly where slopes exceed 30 degrees and water is sufficient. Essentially, when the ratio of slope shear strength to shear stress falls below 1.0, a failure is imminent. This is an example of a threshold phenomenon in nature. At any point in time, a slope or mass of soil may be tending towards the failure threshold. Any action that changes the slope angle or angle of repose, the water content or the cohesiveness of the material can either directly cause a failure or interact indirectly with other factors to cause a premature failure at some later time. The rate of water input to steep sloping soil masses is an important factor. Saturated conditions not only add weight to the soil bulk but reduce internal strength and provide a lubricated slip plane at the soil-bedrock surface. Steep draws, where topography acts to concentrate subsurface water, are particularly hazardous for this reason.

Another predominant erosion process in the Entiat River Basin, particularly on pumice soils, is dry creep. Here, during the dry summer months colluvial action and unstable soils on steep slopes cause material to creep downwards often filling the small interfluves with material. This sediment is washed out rapidly during the rising stream stages due to summer convection storms or fall frontal storm rains.

Dry creep erosion is a major source of road cutbank erosion. Often fall rain carries much of this material into live streams.

Effect of Timber Harvest Activities

Compared to road construction, logging operations cause only minor increases in soil erosion and sediment loads. The highest amount of disturbance to mineral soil would be about 30 percent of area when logged with tractor. Thus, the major portion of the area, even under maximum soil disturbance, would retain the protective cover of forest litter and logging slash. Broadcast burning of slash material can increase erosion potential, depending on fire intensity. Wildfires often are hot enough to consume all forest litter and organic matter leaving mineral soil exposed and highly vulnerable to surface erosion. Soil disturbance associated with slash disposal or seedbed preparation is another potential soil erosion hazard. Areas of high rainfall intensity, excessive surface runoff, and inhibited revegetation are most susceptible to these potential hazards.

The effect of timber removal on occurrence of mass soil movement is thought to be indirect in nature, involving a reduction in soil cohesion with the decay of root systems, and the reduced depletion of soil water by transpiration during the growing season.

Effect of Range Activities

The effect of range activities on erosion and sediment can be significant in two areas: (1) When steep slopes are overgrazed, particularly southwest aspects, and produce accelerated sheet erosion. These sheet erosion areas, under the right conditions of precipitation intensity, and soil are quick to develop rills and resulting gullies. (2) Another source, called accelerated streambank erosion, often occurs where streams bisect fine-textured meadow land soils which are grazed or become concentrated watering areas for cattle, sheep, or horses. The animal trampling often results in severe bank caving.

Effect of Recreational Activities

The effect of various recreational activities on erosion and stream sediment load have not been subject to research and documentation. However, any activity that disturbs the soil or destroys protective organic material is a potential cause of soil erosion. The advent of so-called "off-the-road" vehicles does pose a threat to landscape surface. Temporary roads designed for timber harvest or fire protection are incresingly being used for recreation travel by hunters, campers, sightseers, bike riders, and four-wheel drive enthusiasts. Hiking has increased in popularity in recent years, in addition to horseback riding, resulting in numerous small but concentrated erosion problems. Ski slopes are another potential erosion hazard if subject to erosive rainfall and surface runoff.

Effect of Homesite Construction

Homesite construction, too, increases surface erosion hazard to the extent that roads are required and soil is disturbed or exposed. Although some disturbance is unavoidable, precaution can be taken to minimize soil loss and prevent sediment from reaching the stream system. Intensive homesite construction in a single area can cause significant contributions to local sediment loads, especially when construction of a large number of small home tracts takes place at once.

Appendix N
Special Conservation Practices Guidelines

N. Special Conservation Practices Guidelines

A **Authority.** Counties may develop special permanent type erosion and sediment control practices needed to solve a significant and unique local conservation problem designated high priority in their plan for which national program practices are not adequate.

B **Policies.** Such practices shall meet the following criteria:

1. Provide the most effective solution to soil, water, woodland, or pollution abatement problems identified in the county ACP plan.

2. Be subject to the same policies and standards as other practices in the program.

3. Specify the eligible measures on which Federal cost-sharing may be approved.

4. Have significant public benefits such as prevention of soil loss, conservation of water supply, maintenance of water quality, protection of woodland or wildlife resources, or have other environmental benefits.

5. Comply with herbicide regulations or other farm chemical use requirements.

6. Conform to the applicable standards and permit requirements of any National, State or local regulatory agencies.

7. Specify a life span of NOT LESS THAN 5 YEARS.

C **Approval.** SP practices recommended by the State and/or county group may be included in county or State programs subject to approval of CEPD. (The "SP" practice recommendation shall include a detailed justification indicating compliance with National policies.)

D **Practice Identification.** SP practices shall be identified as SP1, SP2, SP3, etc., as designated by CEPD upon STC request.

E **Technical Responsibility.** As recommended by the COC in consultation with the district conservationist and concurred in by the State development group.

Amend. 1 11-6-78